ROUGH AND TUMBLE ENGINEERING

BY

J. H. MAGGARD

PUBLISHED BY

THE AMERICAN THRESHERMAN

MADISON, WIS.

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A BOOK OF INSTRUCTIONS FOR OPERATORS OF FARM AND TRACTION ENGINES

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JAMES H. MAGGARD

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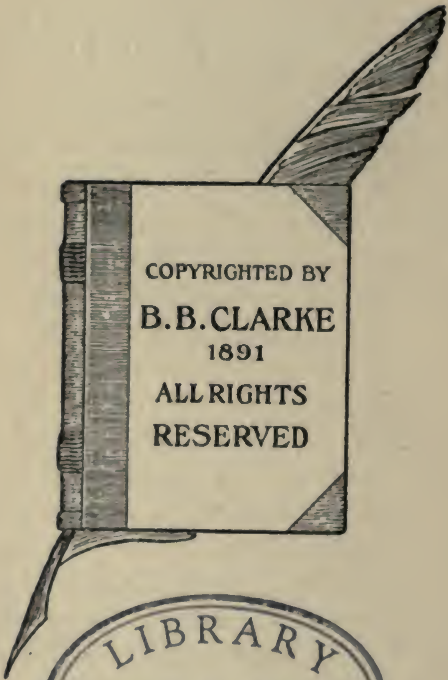


PREFACE.

In placing this book before the public the author wishes it understood that it is not his intention to produce a scientific work on engineering. Such a book would be valuable only to engineers of large stationary engines. In a nice engine room nice theories and scientific calculations are practical. This book is intended for engineers of farm and traction engines, "rough and tumble engineers," who have everything in their favor today, and tomorrow are in mud holes, who with the same engine do eight horse work one day and sixteen horse work the next day. Reader, the author has had all these experiences and you will have them, but don't get discouraged. You can get through them to your entire satisfaction.

Don't conclude that all you need to do is to read this book. It will not make an engineer of you. But read it carefully, use good judgment and common sense, do as it tells you, and my word for it, in one month, you, for all practical purposes, will be a better engineer than four-fifths of the so-called engineers today, who think what they don't know would not make much of a book.

Don't deceive yourself with the idea that what you get out of this will be merely "book learning." What is said in this will be plain, unvarnished, practical facts. It is not the author's intention to use any scientific terms, but plain everyday field talk. There will be a number of things you will not find in this book, but nothing will be left out that would be of practical value to you. You will not find any geometrical figures made up of circles, curves, angles, letters and figures in a vain effort to make you understand the principle of an eccentric. While it is all very nice to know these things, it is not necessary, and the putting of them in this book would defeat the very object for which it was intended. Be content with being a good, practical, everyday engineer, and all these things will come in time.

INTRODUCTORY.

If you have not read the preface on the preceding pages, turn back and read it. You will see that we have stated there that we will use no scientific terms, but plain everyday talk. It is presumed by us that there will be more young men, wishing to become good engineers, read this work than old engineers. We will, therefore, be all the more plain and say as little as possible that will tend to confuse the reader, and what we do say will be said in the same language that we would use if we were in the field, instructing you how to handle your engine. So if the more experienced engineer thinks we might have gone further in some certain points, he will please remember that by so doing we might confuse the less experienced, and thereby cover up the very point we tried to make plain. And yet it is not to be supposed that we will endeavor to make an engineer out of a man who never saw an engine. It is, therefore, not necessary to tell the learner how an engine is made or what it looks like. We are not trying to teach you how to build an engine, but rather how to handle one after it is built; how to know when it is in proper shape and how to let it alone when

it is in shape. We will suppose that you already know as much as an ordinary water boy, and just here we will say that we have seen water haulers that were more capable of handling the engine for which they were hauling water, than the engineer, and the engineer would not have made a good water boy, for the reason that he was lazy, and we want the reader to stick a pin here, and if he has any symptoms of that complaint, don't undertake to run an engine, for a lazy engineer will spoil a good engine, if by no other means than getting it in the habit of loafing.

PART ONE.

In order to get the learner started, it is reasonable to suppose that the engine he is to run is in good running order. It would not be fair to put the green boy onto an old, dilapidated, worn-out engine, for he might have to learn too fast, in order to get the engine running in good shape. He might have to learn so fast that he would get the big head, or have no head at all, by the time he got through with it. And I don't know but that a boy without a head is about as good as an engineer with the big head. We will, therefore, suppose that his engine is in good running order. By good running order we mean that it is all there, and in its proper place, and that with from ten to twenty pounds of steam, the engine will start off at a good lively pace. And let us say here (remember that we are talking of the lone engine, no load considered), that if you are starting a new engine and it starts off nice and easy with twenty pounds, you can make up your mind that you have an engine that is going to be nice to handle and give you but little, if any, trouble. But if it should require fifty or sixty pounds to start it, you want to keep your eyes open;

something is tight; but don't take it to pieces. You might get more pieces than you would know what to do with. Oil the bearings freely and put your engine in motion and run it carefully for a while and see if you don't find something getting warm. If you do, stop and loosen up a very little and start it up again. If it still heats, loosen about the same as before, and you will find that it will soon be all right. But remember to loosen but very little at a time, for a box or journal will heat from being too lose as quickly as from being too tight, and you will make trouble for yourself, for inexperienced as you are, you don't know whether it is too loose or too tight, and if you have found a warm box, don't let that box take all of your attention, but keep an eye on all other bearings. Remember that we are not threshing yet, we have just run the engine out of the shed (and for the sake of the engine and the young engineer, we hope that it did not stand out all winter) and are getting in shape for a good fall's run. In the meantime, to find out if anything heats, you can try your pumps, but to help you along, we will suppose that your pump, or injector, as the case may be, works all right.

Now suppose that we go back where we started this new engine that was slow to start with less than fifty pounds, and when it did start, we watched it carefully and found after oiling thoroughly that nothing heated

as far as we could see. So we conclude that the trouble must be in the cylinder. Well, what next? Must we take off the cylinder head and look for the trouble? Oh, no, not by any means. The trouble is not serious. The rings are a little tight, which is no serious fault. Keep them well oiled and in a day or two ten pounds will start the empty engine in good shape. If you are starting an engine that has been run, the above instructions are not necessary, but if it is a new one these precautions are not out of the way, and a great deal of the trouble caused in starting a new engine can be avoided if these precautions are observed.

It is not uncommon for a hot box to be caused from a coal cinder dropping in the box in shipment. Before starting a new engine, clean out the boxes thoroughly, which can be done by taking off the caps, or top box, and wiping the journal clean with an oily rag or waste. Every engineer should supply himself with this very necessary article, especially if he is the kind of an engineer who intends to keep his engine clean.

The engine should be run slowly and carefully for a while, to give a chance to find out if anything is going to heat before putting on any load.

Now if your engine is all right, you can run the pressure up to the point of blowing off, which is from one hundred and twenty to one hundred and fifty pounds.

Most new pop valves, or safety valves, are set within these pressures. I would advise you to fire to the popping off point, to see that your safety is all right. It is not uncommon for a new pop to stick, and as the steam runs up it is well to try it, by pulling the relief lever. If, on letting it go, it stops the escaping steam at once, it is all right. If, however, the steam continues to escape, the valve sticks in the chamber. Usually a slight tap with a wrench or a hammer will stop it at once, but never get excited over escaping steam, and perhaps here is as good a place as any to say to you, don't get excited over anything. As long as you have plenty of water, and *know* you have, there is no danger.

The young engineer will most likely wonder why we have not said something about the danger of explosions. We did not start to write about explosions. That is just what we don't want to have anything to do with. But, you say, is there no danger of a boiler exploding? Yes. But if you wish to explode your boiler you must treat it very differently from the way we advise. We have just stated, that as long as you have plenty of water, and *know* you have, there is no danger. Well, how are you to know? This is not a difficult thing to know, provided your boiler is fitted with the proper appliances, and all builders of any prominence, at this date, fit their boilers with from two to four try-cocks, and a glass gauge.

The boiler is tapped in from two to four places for the try-cocks, the location of the cocks ranging from a line an inch above the level of the crown sheet, or top of fire box, to eight inches above, depending somewhat on the amount of water space above the crown sheet, as this space differs very materially in different makes of the same sized boiler. The boiler is also tapped on or near the level of the crown sheet, to receive the lower water glass cock and directly above this, for the top cock. The space between shows the safe variation of the water. Don't let the water get above the top of the glass, for if you are running your engine at hard work, you may knock out a cylinder head, and don't let it get below the lower gauge, or you may get your own head knocked off.

Now the glass gauge is put on for your convenience, as you can determine the location of the water as correctly by this as if you were looking directly into the boiler, provided the glass gauge is in perfect order. But as there are a number of ways in which it may become disarranged or unreliable, we want to impress on your mind that you must not depend on it entirely. We will give these causes further on. You are not only provided with the glass gauge, but with the try-cocks. These cocks are located so that the upper and lower cock is on or near the level with the lower and upper end of the glass gauge. With another try-cock about on a level

with the center of the glass gauge, or in other words, if the water stands about the center of the glass it will at the same time show at the middle cock when tried. Now we will suppose that your glass gauge is in perfect condition and the water shows two inches in the glass. You now try the lower cock, and find plenty of water; you will then try the next upper cock and get steam. Now as the lower cock is located below the water line, shown by the glass, and the second cock above this line, you not only see the water line by the glass, but you have a way of proving it. Should the water be within two inches of the top of glass you again have the line between two cocks and can also prove it. Now you can know for a certainty where the water stands in the boiler, and we repeat when you *know* this, there is nothing to fear from this source. A properly constructed boiler never explodes, except from low water or high pressure, and as we have already cautioned you about your safety valve, you have nothing to fear, provided you have made up your mind to follow these instructions, and unless you can do this, let your job to one who can. Since you say you will do as we have directed, we will then go back to the gauges. Don't depend on your glass gauge alone, for several reasons. One is, if you depend on the glass entirly, the try-cocks become limed up and are useless, solely because they are not used.

Some time ago the writer was standing near a traction engine, when the engineer, (I guess I must call him that) asked me to stay with the engine a few minutes. I consented. After he had been gone a short time I thought I would look after the water. It showed about two inches in the glass, which was all right, but as I have advised you, I proposed to know that it was there and thought I would prove it by trying the cocks. But on attempting to try them I found them limed up solid. Had I been hunting an engineer, that fellow would not have secured the job. Suppose before I had looked at the glass, it had bursted, which it is liable to do any time. I would have shut the gauge cocks off as soon as possible to stop the escaping steam and water. Then I would have tried the cocks to find where the water was in the boiler. I would have been in a bad boat, not knowing whether I had water or not. Shortly after this the fellow that was helping the engine run (I guess I will put it that way) came back. I asked him what the trouble was with his try cocks. He said, "Oh, I don't bother with them." I asked him what he would do if his glass should break. His reply was, "Oh, that won't break." Now such an engineer as that spoils many a good engine, and then blames it on the manufacturer. Now this is one good reason why you are not to depend entirely on the glass gauge. Another equally as good

reason is, that your glass may fool you, for you see the try-cocks may lime up, so may your glass gauge cocks, but you say you use them. You use them by looking at them. You are not letting the steam or water escape from them every few minutes and thereby cutting the lime away, as is the case with try-cocks. Now you want to know how you are to keep them open. Well, that is easy. Shut off the stop gauge and open the drain cock at bottom of gauge cock. This allows the water and steam to flow out of the lower cock. Then after allowing it to escape a few seconds, shut off the lower gauge and open the top one, and allow it to blow about the same time. Then shut the drain cock and open both gauge cocks, and you will see the water seek its level, and you can rest assured that it is reliable. This little operation I want you to perform every day you run an engine. It will prevent you from guessing about the water level. I don't want you to guess. I intend that you shall *know*. You remember we said, if you *know* you have water, you are safe, and every one around you will be safe

Now here is something I want you to remember. Never be guilty of going to your engine in the morning and building a fire simply because you see water in the glass. We could give you the names of a score of men who have ruined their engines by doing this very thing.

You, as a matter of course, want to know why this can do any harm. It could not, if the water in the boiler were as high as it shows in the glass, but it is not always that high, and that is what causes the trouble. You probably have lived long enough in the world to know that there are a great many boys in it, and it seems to be second nature with them to turn everything on an engine that is possible to turn. All glass gauge cocks are fitted with a small hand wheel. The small boy sees this about the first thing and he begins to turn it, and he generally turns as long as it turns easy, and when it stops he will try the other one, and when it stops he has done the mischief, by shutting the water off from the boiler, and all the water that was in the glass remains there. You may have stopped work with an ordinary gauge of water, and as water expands when heated, it also contracts when it becomes cool. Water will also simmer away, if there is any fire left in the fire box, especially if there should be any vent or leak in the boiler, and the water may by morning have dropped to as much as an inch below the crown sheet. You approach the engine and on looking at the glass see two or three inches of water. Should you start a fire without investigating any further, you will have done the damage, while if you try the gauge cocks first you will discover that some one has tampered with the engine. The boy did the mischief through no

malicious motives, but we regret to say that there are people in this world who are mean enough to do this very thing, and not stop at what the boy did unconsciously, but after shutting the water in the gauge for the purpose of deceiving you, they then go to the blow-off cock and let enough water out to insure a dry crown sheet. While I detest a human being guilty of such a dastardly trick, I have no sympathy to waste on an engineer who can be caught in this way. So, if by this time you have made up your mind never to build a fire until you know where the water is, you will never be fooled and will never have to explain an accident by saying, "I thought I had plenty of water." You may be fooled in another way. You are aware that when a boiler is fired up, or, in other words, has a steam pressure on, the air is excluded, so when the boiler cools down, the steam condenses and becomes water again, hence the space which was occupied by steam now when cold becomes a vacuum.

Now should your boiler be in perfect shape, we mean perfectly tight, your throttle equally as tight, your pump or injector in perfect condition, and you were to leave your engine with the hose in the tank, and the supply globe to your pump open, you will find on returning to your engine in the morning that the boiler will be nearly if not quite full of water. I have heard engineers say

that someone had been tampering with their engines and storm around about it, while the facts were that the supply being open the water simply flowed in from atmospheric pressure, in order to fill the space made vacant by the condensed steam. You will find further on that all check valves are arranged to prevent any flowing out from the boiler, but nothing to prevent water flowing in. Such an occurrence will do no harm, but the knowing how it was done may prevent your giving yourself away.

A good authority on steam boilers says: "All explosions come either from poor material, poor workmanship, too high pressure, or a too low gauge of water." Now to protect yourself from the first two causes, buy your engine from some factory having a reputation for doing good work and for using good material. The last two causes depend very much on yourself, if you are running your own engine. If not, then see that you have an engineer who knows when his safety valve is in good shape and who knows when he has plenty of water, or knows enough to pull his fire, when for some reason the water should become low. If poor material and poor workmanship were unknown and carelessness in engineers were unknown, such a thing as a boiler explosion would also be unknown.

You no doubt have made up your mind by this time that I have no use for a careless engineer, and let me

add right here that if you are inclined to be careless or forgetful, (they both mean the same thing,) you are a mighty poor risk for an insurance company, but on the other hand, if you are careful and attentive to business, you are as safe a risk as any one. Your own success and the durability and life of your engine depends entirely upon you, and it is not worth your while to try to shift the responsibility of an accident to your engine upon some one else.

If you should go away from your engine and leave it with the water boy, or anyone who might be handy, or leave it alone, as is often done, and something goes wrong with the engine, you are at fault. You had no business to leave it; but you say you had to go to the separator and help fix something there. At the separator is not your place. It is not our intention to tell you how to run both ends of an outfit. We could not tell you if we wanted to. If the men at the separator can't handle it, get someone or get your boss to get someone who can. Your place is at the engine. If your engine is running nicely, there is all the more reason why you should stay by it, as that is the way to keep it running. I have seen twenty dollars' damage done to the separator and two days' time lost all because the engineer was as near the separator as he was to the engine when a root went into the cylinder. Stay with your engine, and if anything

A 22 H. P. HEAVY GEARING AND STEEL WHEEL PLOWING ENGINE

To show this engine and then say it is a Gaar-Scott, reminds us of the fellow who painted a horse, and then wrote under it, "This is a horse."

Gaar-Scott & Co., Richmond, Ind., build a full line of engines and threshers, including 16 and 18 H. P. cast wheel, straw and standard coal burning engines. Also a splendid line of Double Cylinder Traction engines from 16 to 40 H. P. Wood, coal and universal boilers. Saw Mills and Clover Hullers.

See article on Standard Engines, Page 119.

goes wrong at the separator, you are ready to stop and stop quickly, and if you are signaled to start you are ready to start at once. You are therefore making time for your employer or for yourself, and to make time while running a threshing outfit means to make money. There are engineers running engines today who waste time enough every day to pay their wages.

There is one thing that may be a little difficult to learn, and that is to let your engine alone when it is all right. I once gave a young fellow a recommendation to a farmer who wanted an engineer, and afterward noticed that when I happened around he immediately picked up a wrench and commenced to loosen up first one thing and then another. If that engineer ever loses that recommendation he will be out of a job, if his getting one depends on my giving him another one. I wish to say to the learner that that is not the way to run an engine. Whenever I happen to go around an engine, (and I never lose an opportunity), and see an engineer watching his engine, (now don't understand me to mean standing and gazing at it), I conclude that he knows his business. What I mean by watching an engine is, every few minutes let your eye wander over the engine, and you will be surprised to see how quickly you will detect anything out of place. So when I see an engineer watching his engine closely while running, I am most certain to see

another commendable feature in a good engineer, and that is, when he stops his engine he will pick up a greasy rag and go over it carefully, wiping every working part, watching or looking carefully at every part he touches. If a nut is working loose he finds it, if a bearing is hot he finds it. If any part of his engine has been cutting, he finds it. He picks up a greasy rag instead of a wrench, for the engineer that understands his business and attends to it never picks up a wrench unless he has something to do with it. The good engineer takes a greasy rag, and while he is using it to clean his engine he is at the same time carefully examining every part. His main object is to see that everything is all right. If he finds a loose nut or any part out of place, he will then have use for a wrench.

Now what a contrast there is between this engineer and a poor one, and unfortunately there are hundreds of poor engineers running portable and traction engines. You will find a poor engineer very willing to talk. This is a bad habit number one. He cannot talk and have his mind on his work. Beginners must not forget this. When I tell you how to fire an engine you will understand how important it is. The poor engineer is very apt to ask an outsider to stay at his engine while he goes to the separator. This is bad habit number two. Even if the outsider is a good engineer, he does not know

whether the pump is throwing more water than is being used or whether it is throwing less. He can only ascertain this by watching the column of water in the glass, and he hardly knows whether to throw in fuel or not. He don't want the steam to go down, and he don't know at what pressure the pop valve will blow off. There may be a box or journal that has been giving the engineer trouble and the outsider knows nothing about it. There are a dozen other good reasons why bad habit number two is very bad.

If you will watch the poor engineer when he stops his engine, he will, if he does anything, pick up a wrench, go around to the wrist pin, strike the key a little crack, draw down a nut or peck away at something else. You can't see anything for grease and dirt, and when he starts up, ten to one the wrist pin heats, and he stops and loosens it up and then it knocks. Now if he had picked up a rag instead of a wrench, he would not have hit that key, but he would have run his hand over it and if he had found it all right, he would have let it alone, and would have gone over the balance of the engine, and when he started up again his engine would have looked better for the wiping it got and would have run just as well as before he stopped it. Now you will understand why a good engineer wears out more rags than wrenches, while a poor one wears out more wrenches than rags.

Never bother an engine until it bothers you. If you do, you will make lots of grief for yourself.

I have mentioned the bad habits of a poor engineer so that you may avoid them. If you carefully avoid all the bad habits connected with the running of an engine, you will be certain to fall into good habits and will become a good engineer.

TINKERING ENGINEERS

After carelessness, meddling with an engine comes next in the list of bad habits. The tinkering engineer never knows whether his engine is in good shape or not, and the chances are that if he should get it in good shape he would not know enough to let it alone. If anything does actually go wrong with your engine, do not be afraid to take hold of it, for something must be done, and you are the one to do it, but before you do anything be certain that you know what is wrong. For instance, should the valve become disarranged on the valve stem or in any other way, do not try to remedy the trouble by changing the eccentric, or if the eccentric slips do not go to the valve to mend the trouble. I am well aware that among young engineers the impression prevails that a valve is a wonderful piece of mechanism liable to kick out of place and play smash generally. Now let me tell you right here that a valve (I mean the ordinary slide valve, such as is used on traction and portable engines), is one

of the simplest parts of an engine, and you are not to lose any sleep about it, so be patient until I am ready to introduce you to this part of your work.

If your engine runs irregularly, that is, if it runs up to a higher speed than you want, and then runs down, you are likely to say at once, "Oh, I know what the trouble is, it is the governor." Well, suppose it is, what are you going to do about it, are you going to shut down at once and go to tinkering with it? No, don't do that; stay close to the throttle valve and watch the governor closely. Keep your eye on the governor stem, and when the engine starts off on one of its high speed tilts you will see the stem go down through the stuffing box and then stop and stick in one place until the engine slows down below its regular speed, and it then lets loose and goes up quickly and your engine lopes off again. You have now located the trouble. It is very likely in the stuffing box around the little brass rod or governor stem. The packing has doubtless become dry, and by loosening it up and applying oil you may remedy the trouble until such time as you can repack it with fresh packing. Candle wick is as good for this purpose as anything you can use.

But if the governor does not act as I have described and the stem seems to be perfectly free and easy in the box, and the governor still acts queerly, starting off and running fast for a few seconds, and then suddenly con-

cluding to take it easy, letting the engine speed up, see if the governor belt is all right, and if it is, it would be well for you to stop and see if a wheel is not loose. It might be either the little belt wheel or one of the little cog wheels. If you find these are all right, examine the spool on the crank shaft from which the governor is run and you will probably find it loose. If the engine has been run for any length of time, you will always find the trouble in one of these places, but if it is a new one the governor valve might fit a little tight in the valve chamber and you may have to take it out and use a little emery paper to take off the rough projections on the valve. Never use a file on this valve if you can get emery paper, and I would advise you to always have some of it with you. It will often come handy.

Now if the engine should start off at a lively gait and continue to run still faster, you must stop at once. The trouble this time is surely in the governor. If the belt is all right, examine the jamb nuts on the top of the governor valve stem. You will probably find that these nuts have worked loose and the rod is working up, which will increase the speed of the engine. If these are all right, you will find that either a pulley or a little cog wheel is loose. A quick eye will locate the trouble before you have time to stop. If the belt is loose, the governor will lag while the engine will run away. If the wheel is loose,

the governor will most likely stop and the engine will go on a tear. If the jamb nut has worked loose, the governor will run as usual, except that it will increase its speed as the speed of the engine is increased. Now any of these little things may happen and are likely to. None of them are serious, provided you take my advice and remain near the engine. But if you are thirty or forty feet away from the engine and the governor belt slips or gets unlaced, or the pulley gets off, about the first thing the engine would do would be to jump out of the belt, and by the time you can get to it, it will be having a mighty lively time all alone. This might happen once and do no harm, and it might happen again and do a great deal of damage. You are being paid to run the engine and you should stay by it. The governor is not a difficult thing to handle, but it requires your attention.

If I should drop the discussion of the governor at this point you might say that I had not given you any instructions about how to regulate its speed. I really do not know whether it is worth while to say much about regulation, for governors are of different design and are necessarily differently arranged for regulating, but to help young learners I will take the Waters governor, which is found on many threshing and farm engines. You will find on the upper end of the valve or governor stem two little brass nuts. The upper one is a thumb nut

and is made fast to the stem. The second nut is a loose jamb nut. To increase the speed of the engine loosen this jamb nut and take hold of the thumb nut and turn it back slowly, watching the motion of your engine all the while. When you have obtained the speed you require, run the thumb nut down as tight as you can with your fingers. Never use a wrench on these nuts. To slow down or slacken the speed, loosen the jamb nut as before, except that you must run it up a few turns, then taking hold of the thumb nut, turn down slowly until you have the speed required, when you again set the thumb nut securely. In regulating the speed be careful not to press down on the stem when turning, as this will make the engine run a little slower than it will after the pressure of your hand is removed.

If at any time your engine refuses to start with an open throttle, notice your governor stem, and you will find that it has been screwed down as far as it will go. This frequently happens with a new engine, the stem having been screwed down for its protection in transportation.

In traveling through timber with an engine be very careful not to let any over-hanging limbs come in contact with the governor. The governor referred to is the fly ball or "throttling governor." A throttling governor is

one that throttles or controls the flow of steam from boiler to cylinder.

As the speed of the balls increase the centrifugal force tends to force them further from the axis. The mechanism of the governor is such that this "pulling out tendency" forces the valve stem down into the valve chamber and this throttles or reduces the flow or volume of steam to the cylinder.

On all throttling governors, (which is the one used on farm and traction engines), this pulling out tendency of the balls is controlled by a spring, and if you wish to increase the speed of your engine you have only to increase the tension of this spring; and to slow down your engine reduce the tension. The Monarch and Eclipse are governors of this class.

I think what I have said regarding this particular class of governors will enable you to handle any one you may come in contact with, as they are all very much alike in these respects. It is not my intention to take time and space to describe a governor in detail. If you will follow the instructions I have given you the governor will attend to the rest. The other class of governors are known as the fly-wheel or eccentric governor, and governs the engine by the variation of travel or throw of the valve. but you will not find this class of governor on your traction engine.

PART TWO.

WATER SUPPLY.

If you want to be a successful engineer it is necessary to know all about the pump. I have no doubt that many who read this book cannot tell why the old wooden pump (from which he has pumped water ever since he was tall enough to reach the handle) will pump water simply because he works the handle up and down. If you don't know this I have quite a task on my hands, for you must not attempt to run an engine until you know the principle of the pump. If you do understand the old town pump, I will not have much trouble with you, for the same principles are used in the cross head pump. Do not imagine that a cross head pump is a machine to be dreaded. It is only a simple lift and force pump, driven from the cross head. That is where it gets its name, and it doesn't mean that you are to get cross at it if it doesn't work, for nine times out of ten the fault will be yours. While I am well aware that all traction engines do not have cross head pumps, yet with all respect to the builders of engines who do not use them, I am inclined to think that all standard farm engines ought to have one, because it is the most simple, the most economical, and if properly constructed, the most reliable pump made.

A cross head pump consists of a pump barrel, a plunger, one vertical check valve and two horizontal check valves, a globe valve and one stop cock, with more or less piping. We will now locate each of these parts, and will then note the part that each performs in the process of feeding the boiler.

You will generally find the pump barrel located under the cylinder of the engine. It is placed there for several reasons. It is out of the way and it is a convenient place from which to connect it to the cross head by which it is driven. On some engines it is located on the top of or at the side of the cylinder. The plunger is connected with the cross head and in direct line with the pump barrel, and plays back and forth in the barrel. The vertical check valve is placed between the pump and the water supply. It is not absolutely necessary that the first check be a vertical, but a check of some kind must be used. As the water is lifted up to the boiler it is more convenient to use a vertical check at this point. Just ahead and a few inches from the pump barrel is a horizontal check valve. Following the course of the water toward the point where it enters the boiler, you will find another check valve. This is called a "hot water check." Just below this check, or between it and where the water enters the boiler, you will find a stop cock, or it may be a globe valve. They both answer the same purpose. I will

tell you further on why a stop cock is preferable to a globe valve. While the cross head pumps may differ as to location and arrangement, you will find that they require the parts described and that the checks are so placed that they bear the same relation to each other. No fewer parts can be used in a pump required to lift water and force it against steam pressure. More check valves may be used, but it would not do to use less. Each has its work to do, and the failure of one defeats all the others. The pump barrel is a hollow cylinder, the chamber being large enough to admit the plunger, which varies in size from ⅝ of an inch to 1 inch in diameter, depending upon the size of the boiler to be supplied. The barrel is usually a few inches longer than the stroke of the engine, and is provided at the cross head end with a stuffing box and nut. At the discharge end it is tapped out to admit of piping to conduct water from the pump. At the same end and at the extreme end of the travel of the plunger it is tapped for a second pipe, through which water from the supply reaches the pump barrel. The plunger is usually made of steel and turned down to fit snug in the chamber, and is long enough to play the full stroke of the engine between the stuffing box and point of supply and to connect with the driver on the cross head. Now, we will take it for granted, that, to begin with, the pump is in good order, and we will start it up

a stroke at a time and watch it work. When we start the pump we must open the little pet cock between the two horizontal check valves. The globe valve must be open so as to let the water in. A check valve, whether it is vertical or horizontal, will allow water to pass through it one way only, if it is in good working order. If the water will pass through both ways, it is of no account. Now, the engine starts on the outward stroke and draws the plunger out of the chamber. This leaves a space in the barrel which must be filled. Air cannot get into it, because the pump is in perfect order, neither can the air get to it through the hose, as it is in the water, so that the air pressure on the surface of the water causes it to flow up through the pipes, through the first check valve and into the pump barrel. If the engine has a 12-inch stroke, and the plunger is 1 inch in diameter, we have a column of water in the pump 12 inches long and 1 inch in diameter.

The engine has now reached its outward stroke and starts back. The plunger comes back with it and takes the space occupied by the water, which must get out of the way for the plunger. The water came up through the first check valve, but it can's get back that way, as we have stated. There is another check valve just ahead, and as the plunger travels back it drives the water through this second check. When the plunger reaches

the end of the backward stroke, it has driven the water all out. It then starts forward again, but the water which has been driven through the second check cannot get back and this space is again filled from the supply. The first four or five strokes of the plunger are required to fill the pipes between the second check valve and the hot water check valve. If the gauge shows 100 pounds of steam, the hot water check is held shut by 100 pounds pressure, and when the space between the check valves is filled with water, the next stroke of the plunger will force the water through the hot water check valve, which is held shut by the 100 pounds steam pressure so that the pump must force the water against this hot water check valve with a power greater than 100 pounds pressure. If the pump is in good condition, the plunger does its work and the water is forced through into the boiler. A clear sharp click of the valves at each stroke of the plunger is certain evidence that the pump is working well.

The small drain cock is placed between the horizontal checks to assist in starting the pump, to tell when the pump is working, and to drain the water off to prevent freezing. When the pump is started this drain cock should be opened, and the hot water in the pipes drained off. The globe valve should then be opened. After a few strokes of the plunger, and water begins to flow out

through the drain cock, the latter must be closed, you may be reasonably certain now that the pump is working all right. If at any time you are in doubt as to whether the pump is forcing the water through the pipes, you can easily ascertain by opening this drain cock. It will always discharge cold water when the pump is working. Another way to tell if the pump is working, is by placing your hand on the first two check valves. If they are cold the pump is working all right, but if they are warm, the cold water is not being forced through them.

A stop cock should be used next to the boiler, as you can ascertain whether it is open or shut by merely looking at it, while the globe valve can be closed by some meddlesome party and you would not discover it, until some part of your pump is broken by forcing water against it.

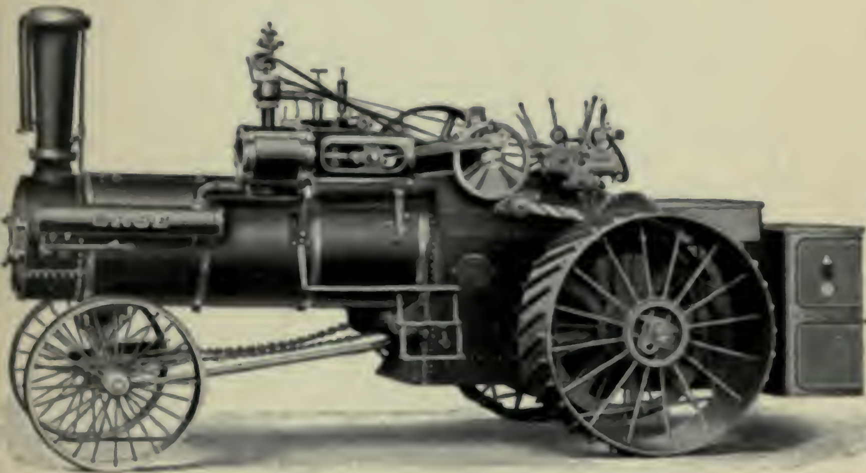
Now if I were to sit down and "Talk engine" to you, I no doubt would say things that would need explaining, or, in other words ought to be made clearer, for instance on page 9, I say, (In referring to an engine whose rings might be a "little tight,") "keep them well oiled." Now this means that you must keep your lubricator in good shape. That is you must see that the cylinder is getting plenty of oil, for this is the only way to "oil the rings."

It is very important when the pump fails to work to ascertain what the trouble is. If it should stop sud-

denly, examine the tank and ascertain if you have any water. If you have sufficient water, it may be that there is air in the pump chamber, and the only way that it can get in is through the stuffing box around the plunger, if the pipes are all tight. Give this stuffing nut a turn, and if the pump starts off all right, you have found the trouble, and it would be well to re-pack the pump the first chance you get.

If the trouble is not in the stuffing box, go to the tank and see if there is anything over the screen or strainer at the end of the hose. If there is not, take hold of the hose and you can tell if there is any suction. Then ascertain if the water flows in and then out of the hose again. You can tell this by holding your hand loosely over the end of the hose. If you find that it draws the water in and then forces it out again, the trouble is with the first check valve. There is something under it which prevents its shutting down. If, however, you find that there is no suction at the end of the hose examine the second check. If there should be something under it, it would prevent the pump from working, because when the plunger starts back, if the check fails to hold, the water will flow back and fill the pump barrel again and there will be no suction.

The trouble may, however, be in the hot water check, and it can always be told whether it is in the second check



THE CASE ENGINE

which you see here is possibly familiar to more readers of Rough and Tumble Engineering than any I can show, and it is scarcely necessary to say that it is built by the **J. I. Case Threshing Machine Co., Racine, Wisconsin.**

See article on Standard Engines, Page 119.

or hot water check by opening the little drain cock. If the water which goes out through it is cold, the trouble is in the second check; but, if hot water and steam are blown out through this little drain cock, the trouble is in the hot water check, or the one next to the boiler. This check must never be tampered with without first turning the stop cock between it and the boiler. The valve can then be taken out and the obstruction removed. Be very careful never to take out the hot water check without closing the stop cock, for if you do you will get badly scalded; and never start the pump without opening this valve, for if you do, it will burst the pump.

The obstruction under the valves is sometimes hard to find. A young man in southern Iowa got badly fooled by a little pebble about the size of a pea, which got into the pipe, and when he started his pump the pebble would be forced up under the check and let the water back. When he took the check out the pebble was not there, for it had dropped back into the pipe. You will see that it is necessary to make a careful examination, and not get mad, pick up a wrench and whack away at the check valve, bruising it so that it will not work. Remember that it would work if it could, and make up your mind to find out why it don't work. A few years ago I was called several miles to see an engine on which the pump would not work. The engine had been idle for two days

and the engineer had been trying all that time to make the pump work. I took the cap off of the horizontal check, just forward of the pump barrel, and took the valve out and discovered that the check was reversed. I told the engineer that if he would put the check in so that the water could get through, he would have no more trouble. This fellow had lost his head. He was completely rattled. He insisted that "*the valve had always been on that way*," although the engine had been run two years.

Now the facts in this case were as follows: The old check valve in place of the one referred to had been one known as a stem valve, or floating valve. This stem by some means had broken off, but it did not prevent the valve from working. The stem, however, worked forward till it reached the hot water check, and lodged under the valve, which prevented this check from working and his pump refused to work; the engineer soon found where the stem had broken off, and instead of looking for it, sent to town for a new check. After putting this on the pump now refused to work for two reasons. One was, he had not removed the broken stem from the hot water check, and another was, that the new check was in wrong end to. After wasting another hour or two he finally found and removed the stem from the hot water check, but his pump still refused to work. And then as the

boys say, "he laid down," and when I called his attention to the new valve being in wrong, he was so completely rattled that he made use of the above expression.

There are other causes that would prevent the pump from working besides lack of packing and obstructions under the valves. The valve may stick. When it is raised to allow the water to flow through, it may stick in the valve chamber and refuse to settle back in the seat. This may be caused by a little rough place in the chamber, or a little projection on the valve, and can generally be remedied by tapping the under side of the check with a wrench or hammer. Do not strike it so hard as to bruise the check but simply tap it. If this don't remedy the trouble, take the valve out, bore a hole in a board about ½ inch deep and large enough to permit the valve to be turned. Drop a little emery dust in this hole. If you haven't any emery dust, scrape some grit from a common whetstone. If you have no whetstone, put some very fine sand or gritty soil in the hole, put the valve on top of it, put your brace on the valve and turn it vigorously for a few minutes, and you will remove all roughness.

Constant use may somtimes make a burr on the valve which will cause it to stick. Put it through the above course and it will be as good as new. If this little pro-

cess was generally known, a great deal of trouble and annoyance could be avoided.

It will not be necessary to describe other styles of pumps. If you know how to run the cross head pump you can run any of the others. Some engines have a cross head pump only. Others have an independent pump. Others have an injector, or inspirator, and some have both cross head pump and injector. I think a farm engine should be supplied with both.

It is neither wise nor necessary to go into a detailed description of an injector. The young reader will be likely to become convinced that if an injector works for five minutes, it will continue to work, if the conditions remain the same. If the water in the tank does not become heated, and no foreign substance is permitted to enter the injector, there is nothing to prevent its working properly as long as the conditions are within the range of a good injector. It is a fact that with all injectors as the vertical distance the injector lift is increased, it requires a greater steam pressure to start the injector, and the highest steam pressure at which the injector will work is greatly decreased. If the feed water is heated, a greater steam pressure is required to start the injector and it will not work with as high steam pressure. The capacity of an injector is always decreased as the lift is increased, or the feed water heated. To

AVERY UNDERMOUNTED ENGINE

Here is an engine which the writer has been watching since its introduction, and I am now more than pleased to list it among the standard engines of America. It seems a waste of time and space to say that it is built by the Avery Co., of Peoria, Ill., as its appearance is its own name plate. Remember the "Yellow Fellow."

See article on Standard Engines, Page 119.

obtain the most economical results the proper sized injector must be used. When the exact quantity of water consumed per hour is known it can be easily determined, from the capacities given in the price lists, which sized injector must be selected.

An injector must always be selected having a maximum capacity in excess of the water consumed. If the exact amount of water consumed per hour is not known, and cannot be easily determined, the proper size can be approximately determined from the nominal H. P. of the boiler. The usual custom has been to allow 7½ gallons of water per hour per H. P. which is a safe rule for the ordinary type of boiler.

WHAT A GOOD INJECTOR OUGHT TO DO

With cold feed water, a good injector with a two foot lift ought to start with 25 pounds pressure and work up to 150 pounds. With an 8 foot lift, it ought to start at 30 pounds and work up to 130. With feed water heated to 100 degrees Fahrenheit it should start with a two foot lift at 26 pounds pressure and work up to 120 pounds and at 8 feet from 33 up to 100 pounds. You will see by this that conditions, consisting of variation of temperature in the feed water and different lifts, change the efficiency of your injector very materially, and the water can soon get beyond the capacity of your injector to work at all. The above refers more particularly to the single

tube injector. The double tube injector, under the same conditions as above, should work from 14 pounds to 250, and from 15 to 210, but as this injector is not generally used on farm engines you will most likely not meet with it very often.

The injector should not be placed too near the boiler, as the heat therefrom will make it difficult to start the injector each time after it has been standing idle.

If the injector is so hot that it will not lift the cold water, there is no way of cooling it except by applying the water on the outside. This is most effectively done by covering the injector with a cloth and pouring water over the cloth. If, after the injector has become cool, it still refuses to work, you may be sure that there is some obstruction in it that must be removed. This can be done by taking off the cap, or plug-nut, and running a fine wire through the cone valve or cylinder valve. The automatic injector requires only the manipulation of the steam valve to start it. There are other makes that require the opening of the steam valve first. It requires some little tact to start an injector (and you will discover that tact is the handiest tool you can have to make you a good engineer). To start an injector of the Penberthy type; first give it sufficient steam to lift the water, allowing the water to escape at the overflow for a moment, or long enough to cool the injector, then with a

quick turn shut off and open up the water supply which requires merely a twist of the wrist.

If the injector fails to take hold at once don't get ruffled but repeat the above move a few times and you will soon start it, and if you have tact (it is only another word for natural ability) you will need no further instructions to start your injector. But remember that no injector can work coal cinders or chaf and that all joints must be air tight. Don't forget this.

It is now time to give some attention to the heater. While the heater is no part of the pump, it is connected with it and does its work between the two horizontal check valves. Its purpose is to heat the water before it passes into the boiler. The water on its way from the pump to the boiler is forced through a coil of pipes around which the exhaust steam passes on its way from the cylinder to the exhaust nozzle in the smokestack.

The heaters are made in several different designs, but it is not necessary to describe all of them, as they require little attention and they all answer the same purpose. The most of them are made by the use of a hollow bedplate with steam fitted heads or plates. The water pipe passes through the plate at the end of the heater into a hollow chamber, where it is joined to a coil of pipe the other end of which passes back through the head or plate to the hot water check valve and thence into the boiler.

The steam enters the cylinder from the boiler, varying in degrees of heat from 300 to 500. After acting on the piston head, it is exhausted directly into the chamber or hollow bed-plate through which the heater pipes pass. The water, when it enters the heater, is as cold as when it left the tank, but the steam which surrounds the pipes has lost but little of its heat, and by the time the water passes through the coil of pipes it is heated to nearly the boiling point and can be introduced into the boiler with little tendency to reduce the steam pressure. This use of the exhaust steam is economical, as it saves fuel. Besides it is considered injurious to pump cold water directly into a hot boiler.

If your engine is fitted with both cross head pump and injector, it is better to use the injector for pumping water when the engine is not running. The injector heats the water almost as hot as the heater. If your engine is running and doing no work, use your injector and stop the pump; for, while the engine is running light, the small amount of exhaust steam is not sufficient to heat the water and the pressure will be reduced rapidly. You will understand, therefore, that the injector is intended principally for emergency rather than for general use. It should always be kept in order, for, should the pump refuse to work, you have only to start your injector and use it until such time as you can remedy the trouble.

We have now explained how you get your water supply. You understand that you must have water first and then fire. Be sure that you have the water supply first.

THE BLOWER

The blower is an appliance for creating artificial draught and consists of a small pipe leading from some point above the water line into the smoke stack, directly over the tubes, and it should terminate with a small nozzle pointing directly to the top and center of the stack; this pipe is fitted with a globe valve. When it is required to rush your fire, you can do so by opening this valve and allowing the steam to escape into the stack. The force of the steam tends to drive the air out of the stack and smoke box, thus creating a strong draught. But you say, "What if I have no steam?" Well, then don't blow, and be patient till you have enough to create a draught. It has been my experience that there is nothing gained by putting on the blower before having fifteen pounds of steam, as less pressure than this will create but little draught and the steam will escape about as fast as it can be generated. Be patient and don't be everlastingly punching at the fire box; shut the door and go about your business and let the fire burn.

Must the blower be used while working the engine? No. The exhaust steam which escapes into the stack,

does exactly what we stated the blower does, and if it is necessary to use the blower in order to keep up steam, you can conclude that your engine is in bad shape, and yet there are times when the blower is necessary, even when your engine is in the best of condition. For instance, when you have poor fuel and are working your engine very light, the exhaust steam may not be sufficient to create enough draught for poor coal, or wet or green wood. But if you are working your engine hard the blower should never be used. If you have bad fuel and it is necessary to stop your engine you will find it very convenient to put on the blower slightly, in order to hold your steam and keep the fire lively until you start again.

It will be a good plan for you to take a look at the nozzle on the blower now and then, to see that it does not become limed up and to see that it is not turned to the side so that it directs the steam to the side of the stack. Should it do this, you will be using the steam and getting but little, if any, benefit. It will also be well for you to remember that you can create too much draught as well as too little; too much draught will consume your fuel and produce but little steam.

A GOOD FIREMAN

What constitutes a good fireman? You no doubt have heard the expression: "Where there is so much smoke,

there must be some fire." Well, that is true, but a good fireman don't make much smoke. We are speaking of firing with coal, now. If I can see the smoke ten miles from a threshing engine, I can tell what kind of a fireman is running the engine and if there is a continuous cloud of black smoke being thrown out of the smokestack, I make up my mind that the engineer is having all he can do to keep the steam up, and also conclude that there will not be much coal left by the time he gets through with the job; while on the other hand, should I see at regular intervals a cloud of smoke going up, and lasting for a few moments, and for the next few moments see nothing, then I conclude that the engineer of that engine knows his business, and that he is not working hard; he has plenty of steam all the time, and has coal left when he is through. So let us go and see what makes this difference and learn a valuable lesson. We will first go to the engine that is making such a smoke, and we will find that the engineer has a big coal shovel just small enough to allow it to enter the fire door. You will see the engineer throw in about two, or perhaps three shovelfuls of coal, and as a matter of course, we will see a volume of black smoke issuing from the stack. The engineer stands leaning on his shovel watching the steam gauge, and he finds that the steam doesn't run up very fast. About the time the coal gets hot enough to con-

sume the smoke, we will see him drop his shovel, pick up a poker, throw open the fire door and commence a vigorous punching and digging at the fire. This starts the black smoke again, and about this time we will see him down on his knees with his poker, punching at the underside of the grate bars. When he is through with this operation the smoke is coming out less dense, and he thinks it time to throw in more coal, so he does. This is his regular routine and he has hard work keeping up steam. You may say the picture is overdrawn, but it is not. You can see it any day in the threshing field. The engineer that fires in this way, works hard, burns a great amount of coal, and wonders why he does not get better results.

Before leaving him let us take a look at his firebox, and we will see that it is full of coal, at least up to the level of the door. We will also see quite a pile of ashes under the ash pan. You can better understand the disadvantage of this way of firing after we visit the next man. I think a good way to know how to do a thing is to know also how not to do it.

We will now go across to the man who is making but little smoke, and making that at regular intervals. We will be likely to find that he has only a little hand shovel. He picks this up, takes a small amount of coal, opens the fire door and spreads the coal evenly over the

grates. He does this quickly and shuts the door; for a minute black smoke is thrown out, but only for a minute. Why? Because he only threw in enough to replenish the fire, and not to choke it in the least, and in a minute the heat is great enough to consume all the smoke before it reaches the stack, and as smoke is unconsumed fuel, he gains that much if he can consume it. We will see this engineer standing around for the next few minutes perfectly at ease. He is not in the least afraid of his steam going down. At the end of three to five minutes, owing to the amount of work he is doing, you will see him pick up his little shovel and throw in a little more coal; he does exactly as he did before, and if we stay there for an hour we will not see him pick up a poker. We will look in at his firebox, and we will see what is called a "thin fire," but every part of the firebox is hot. We will see but a small pile of ashes under the engine and he is not working hard.

If you happen to be thinking of buying an engine, you will say that this last fellow "has a dandy engine," "that is the kind of an engine I want," when the facts in the case may be that the first man had the better engine, but didn't know how to fire it. Now, don't you see how important it is that you know how to fire an engine? I am aware that some big coal wasters will say, "It is easy to talk about firing with a little hand shovel, but

just get out in the field as we do and get some of the kind of fuel we have to burn, and see how you get along." Well, I am aware that you will have some bad coal. It is much better to handle bad coal in a good way than to handle good coal in a bad way. Learn to handle your fuel in the proper way and you will be a good fireman. Don't get careless and then blame the coal for what is your own fault. Be careful about this, you might give yourself away. I have seen engineers make a big kick about the fuel and claim that it was no good, when some other fellow would take hold of the engine and have no trouble whatever.

Don't allow any one to be a better fireman than yourself. You will see a good fireman do exactly as I have stated. He fires often, always keeps a level fire, never allows the coal to get up to the lower tubes, always puts in coal before the steam begins to drop, keeps the fire door open as little as possible, preventing any cold air from striking the tubes, which will not only check the steam, but is injurious to the boiler.

It is no small matter to know just how to handle your dampers; don't allow too much of an opening here. You will keep a much more even fire by keeping the damper down, just allowing draught enough to allow free combustion; more than this is a waste of heat.

Get all out of the coal you can, and save all you get.

Learn the little points that half the engineers never think of.

WOOD

You will find wood quite different in some respects, but the good points you have learned will be useful now. Fire quick and often, but unlike coal, you must keep your fire box full. Place your wood as loosely as possible. I mean by this, place in all directions to allow the draught to pass freely through it. Keep adding a couple of sticks as fast as there is room and then don't disturb them. Use short wood and fire close to the door. When firing with wood I would advise you to keep your screen down. There is much more danger of setting fire with wood than with coal.

If you are in a dangerous place, owing to the wind and the surroundings, don't hesitate to state your fears to the man for whom you are threshing. He is not supposed to know the danger as well as you, and if, after your advice, he says go ahead, you have placed the responsibility on him; but even after you have done this, it sometimes shows a good head to refuse to fire with wood, especially when you are required to fire with old rails, which is a common fuel in a timbered country. While they make a hot fire in a firebox, they sometimes start a hot one outside of it. It is part of your business to be as careful as you can. What I mean is take reasonable

precaution in looking after the screen in the stack. If it burns out get a new one. With reasonable diligence and care, you will never set anything on fire, while on the other hand, a careless engineer may do quite a lot of damage.

There is fire about an engine, and you are provided with the proper appliances to control it. See that you do it.

WHY GRATES BURN OUT

Grates burn through carelessness. You may as well make up your mind to this at the start. You never saw grate bars burn out with a clean ash box. They can only be burned by allowing the ashes to accumulate under them till they exclude the air when the bars at once become red hot. The first thing they do is to warp, and if the ashes are not removed at once, the grate bar will burn off. Carelessness is neglecting something which is a part of your business, and as part of it is to keep your ash box clean, it certainly is carelessness if you neglect it. Your coal may melt and run down on the bars, but if the cold air can get to the grates, the only damage this will do is to form a clinker on the top of grates, and shut off your draught. When you find that you have this kind of coal you will want to look after these clinkers.

Now if you should have good success in keeping steam, keep improving on what you know, and if you run on

1000 pounds of coal today, try and do it with 900 tomorrow. That is the kind of stuff a good fireman is made of.

But don't conclude that you can do the same amount of work each day in the week on the same amount of fuel, even should it be of the same kind. You will find that with all your care and skill, your engine will differ very materially both as to the amount of fuel and water that it will require, though the conditions may apparently be the same.

This may be as good a time as any to say to you, remember that a blast of cold air against the tubes is a bad thing, so be careful about your firedoor; open it as little as possible; when you want to throw in fuel, don't open the door, and then go a rod away after a shovel of coal. I will say here that I have seen this thing done by men who flattered themselves that they were about at the top in the matter of running an engine. That kind of treatment will ruin the best boiler in existence. I don't mean that once or twice will do it, but to keep it up will do it. Get your shovel of coal and when you are ready to throw it in, open the door quickly and close it at once. Make it one of your habits to do this, and you will never think of doing it in any other way. If it becomes necessary to stop your engine with a hot fire and a high pressure of steam, don't throw your door open, but drop your damper and open the smoke box door.

If, however, you only expect to stop a minute or two, drop your damper, and start your injector if you have one. If you have none, get one.

An independent boiler feeder is a very nice thing, if constructed on the proper principles. You can't have your boiler too well equipped in this particular.

PART THREE.

A boiler should be kept clean, outside and inside. Outside for your own credit, and inside for the credit of the manufacturers. A dirty boiler requires hard firing, takes lot of fuel, and is unsatisfactory in every way.

The best way to keep it clean is not to let it get dirty. The place to begin work, is with your "water boy;" pursuade him to be very careful of the water he brings you; if you can't succeed in this, ask him to resign.

I have seen a water-hauler back into a stream, and then dip the water from the lower side of the tank, the muddy water always goes down stream and the wheels stir up the mud; and your bright water hauler dips it into the tank, while if he had dipped it from the upper side he would have gotten clear water. However, the days of dipping water are past, but a water boy that will do as I have stated is just as liable to throw his hose into the muddy water or lower side of the tank as on the upper side, where it is clear. See that he keeps his tank clean. We have seen tanks with one-half an inch of mud in the bottom. We know that there are

times when you are compelled to use muddy water, but as soon as it is possible to get clear water make him wash out his tank, and don't let him haul it around till the boiler gets it all.

Allow me just here to tell you how to construct a good tank for a traction engine. You can make the dimensions to suit yourself, but across the front end and about two feet back fit a partition or second head; in the center of this head and about an inch from the bottom, bore a two-inch hole. Place a screen over this hole on the side next the rear, and on the other or front side, put a valve. You can construct the valve in this way: Take a piece of thick leather, about four inches long, and two and a half inches wide; fit a block of wood (a large bung answers the purpose nicely) on one end, trimming the leather around one side of the wood, then nail the long part of the valve just above the hole, so that the valve will fit nicely over the hole in the partition. When properly constructed, this valve will allow the water to flow into the front end of the tank, but will prevent its running back. So, when you are on the road with part of a tank of water, and start down hill, this front part fills full of water, and when you start up hill, it can not get back, and your pumps will work as well as if you had a full tank of water. Without this arrangement you cannot get your pumps to

work well in going up a steep hill with anything less than a full tank. Now, this may be considered a little out of the engineer's duty, but it will save lots of annoyance if he has his tank supplied with this little appliance, which is simple but does the business.

A boiler should be washed out and not blown out. I believe I am safe in saying that more than half the engineers of threshing engines today depend on the "blowing out" process to clean their boilers. I don't intend to tell you to do anything without giving my reasons. We will take a hot boiler, for instance; say, under 50 pounds of steam. We will, of course, take out the fire. It is not supposed that anyone will attempt to blow out the water with any fire in the firebox. We will, after removing the fire, open the blow-off valve, which will be found at the bottom or lowest water point. The water is forced out very rapidly with the pressure, and the last thing that comes out is the steam. This steam keeps the entire boiler hot till everything is blown out, and the result is that all the dirt, sediment and lime is baked solid on the tubes and sides of the firebox. But you say you know enough not to blow off at 50 pounds pressure. Well, we will say 5 pounds, then. You will admit that the boiler is not cold by any means, even at only 5 pounds, and if you know enough not to blow off at 50 pounds, you

certainly know that at 5 pounds pressure the damage is not entirely avoided. As long as the iron is hot, the dirt will dry out quickly, and by the time the boiler is cold enough to force cold water through it safely, the mud is dry and adheres closely to the iron. Some of the foreign matter will be blown out, but you will find it a difficult matter to wash out what sticks to the hot iron.

I am aware that some engineers claim that the boiler should be blown out at about 5 pounds or 10 pounds pressure, but I believe in taking the common sense view. They will advise you to blow out at a low pressure, and then, as soon as the boiler is cool enough, to wash it thoroughly.

Now, if you must wait till the boiler is cool before washing, why not let it cool with the water in it? Then, when you let the water out, your work is easy, and the moment you begin to force water through it, you will see the dirty water flowing out at the manhole or hand hole. The dirt is soft and washes very easily; but, if it had dried on the inside of the boiler while you were waiting for it to cool, you would find it very difficult to wash off.

You will observe, I said to force the water through the boiler, and to do this you must use a force pump. No engineer ought to attempt to run an engine without a

force pump. It is one of the necessities. You may ask, can't I wash out a boiler without a force pump? Oh, yes! You can do it just like some people do business. But I started out to tell you how to keep your boiler clean, and the way to do it is to wash it out, and the way to wash it out is with a good force pump. There are a number of good pumps made, especially for threshing engines. They are fitted to the tank for lifting water for filling, and are fitted with a discharge hose and nozzle.

You will find at the bottom of the boiler one or two hand hole plates—if your boiler has a water bottom—if not, they will be found at the botom of the sides of the firebox. Take out these hand hole plates. You will also find another plate near the top, on the firebox end of the boiler; take this out, then open up the smoke box door and you will find another hand hole plate or plug near the lower row of tubes; take this out, and you are ready for your water works, and you want to use them vigorously. Don't throw in a few bucketfuls of water, but direct the nozzle to every part of the boiler, and don't stop as long as there is any muddy water flowing at the bottom hand holes. This is the way to clean your boiler, and don't think that you can be a success as an engineer without this process. A thorough washing out once a week is none too often. If you want

satisfactory results from your engine, you must keep a clean boiler, and to keep it clean requires care and labor. If you neglect it you may expect trouble. If you blow out your boiler hot, or if the mud and slush bakes on the tubes, a scale is formed, which decreases the boiler's evaporating capacity. You must, therefore, in order to make a sufficient amount of steam, increase the amount of fuel used, which is of itself a source of expense, to say nothing of the extra labor and the danger of causing the tubes to leak from the increased heat produced in the firebox in order to make steam sufficient to do the work.

You must not expect economy of fuel, and at the same time keep a dirty boiler. Don't condemn a boiler because of hard firing until you know it is clean, and don't say it is clean when it can be shown to be half full of mud.

SCALE

Advertisements say that certain compounds will prevent scale in boilers, and I think they tell the truth, as far as they go; but they don't say what the result may be on iron. I will not advise the use of any of these preparations, for several reasons. In the first place, certain chemicals will successfully remove the scale formed by water charged with bicarbonate of lime, and have no effect on water charged with sulphate of lime. Some

kinds of bark—summac, logwood, etc.,—are sufficient to remove the scale from water charged with magnesia or carbonate of lime, but they are injurious to the iron owing to the tannic acid with which they are charged. Vinegar, rotten apples, slop, etc., owing to their containing acetic acid, will remove scale, but this is even more injurious to the iron than the barks. Alkalies of any kind, such as soda, will be found good in water containing sulphate of lime, by converting it into a carbonate and thereby forming a soft scale, which is easily washed out, but these have their objections, for, when used to excess, they cause foaming.

Petroleum is not a bad thing in water where sulphate of lime prevails but you should use only the refined, as crude oil sometimes helps to form a very injurious scale.

Carbonate of soda and corn-starch have been recommended as a scale preventative, and I am inclined to think they are as good as anything, but as we are out in the country most of the time, I can tell you of a simple little thing that will answer the same purpose, and can usually be had with little trouble. Every Monday morning just dump a hatful of potatoes into your boiler, and Saturday night wash the boiler out, as I have already suggested, and when the fall's run is over there will not be much scale in the boiler.

CLEAN FLUES.

We have been urging you to keep your boiler clean. Now, to get the best results from your fuel, it will also be necessary to keep your flues clean. As soot and ashes are non-conductors of heat, you will find it very difficult to get up steam with a coating of soot in your tubes. Most factories furnish with each engine a flue cleaner and rod. This cleaner should be made to fit the tubes snug, and should be forced through each separate tube every morning before building a fire. Some engineers never touch their flues with a cleaner, but choke the exhaust sufficiently to create sufficient draught as to clean the flues. This works the engine at a great disadvantage, besides being much more liable to pull the fire out at the top of the smokestack. If it were not necessary to create draught by reducing your exhaust nozzle, your engine would run much nicer and be much more powerful. However, you must reduce it sufficiently to give draught, but don't impair the power by trying to make the engine clean its own flues. As a matter of fact tubes can not be cleaned perfectly in this way. They must be scraped clean. I think ninety per cent of the fires started by traction engines can be traced to the engineer having his engine choked at the exhaust nozzle. This is dangerous for the reason that the excessive draught created throws fire out at the stack. It cuts the power of

the engine by creating back pressure. We will illustrate this: If you close the exhaust entirely the engine will not run. This being true, you can readily understand that partly closing it will weaken the engine to a certain extent. So, remember that the nozzle has something to do with the power of the engine, and you can see why the fellow that makes his engine clean its own flues is not the brightest engineer in the world.

While it is not my intention to encourage the foolish habit of pulling engines, to see which is the best puller, yet should you get into this kind of a test, you can show the other fellow a trick by dropping the exhaust nozzle off entirely, and no one need know it. Your engine will not appear to be making any effort, either, in making the pull. Many a test has been won more through the shrewdness of the operator than the superiority of the engine.

The knowing of this little trick may also help you out of a bad hole some time when you want a little extra power. And this brings us to the point to which I want you to pay special attention. The majority of engineers, when they want a little extra power, give the safety valve a twist.

Now, I have already told you to carry a good head of steam, anywhere from 100 to 120 pounds of steam is good pressure and is plenty. If you have your valve set

to blow off at 115 pounds leave it there. Don't screw it down every time you want more power, for if you do you will soon have it up to 125 pounds, and then if you want more steam at some other time you will find yourself screwing it down again, and what was really intended for a safety valve loses all its virtue as a safety, as far as you and those around you are concerned. If you know you have a good boiler you are safe in setting it at 125 pounds, provided you are careful to not set it up to any higher pressure. But my advice to you is that if your engine won't do the work required of it at 115 pounds, you had best do what you can with it until you can get a larger one.

A safety valve is exactly what its name implies, and there should be a heavy penalty for anyone taking that power away from it.

If you refuse to set your safety down at any time, it does not imply that you are afraid of your boiler, but rather you understand your business and realize your responsibility.

I stated before what you should do with the safety valve in starting a new engine. You should also examine it and test it every few days. See that it does not become slow to work. You should note the pressure every time it blows off. You know where it ought to blow off, so don't allow it to stick or hold the steam be-

yond this pressure. If you are careful about this, there is no danger about its sticking some time when you don't happen to be watching the gauge. The steam gauge will tell you when the pop ought to blow off, and you should see that it does. The following dialogue occurred in the writer's hearing:

A big fat duffer came into the shop with a steam gauge in his hand, and throwing it down on the bench said, "That gauge is no good."

"What's the matter with it?" said the superintendent. "Why I tell you it's no good, it went up to 180 pounds before the pop blowed off."

"It did, did it?" said the superintendent.

"Yes, it did."

"How do you know the pop isn't off?"

And fatty's face showed clearly that a new idea had hit him hard.

His gauge was tested with the standard gauge in the engine room and found to correspond with it to a pound. The superintendent of the shop told him to go back and look after his pop valve. He picked up his "no good" gauge and walked out, and he actually appeared to be thinking about something.

PART FOUR.

STEAM GAUGE

Some engineers call a steam gauge a "clock." I suppose they do this because they think it tells them when it is time to throw in coal, and when it is time to quit, and when it is time for the safety valve to blow off. If that is what they think a steam gauge is for, I can tell them that it is time for them to learn differently.

It is true that in a certain sense it does tell the engineer when to do certain things, but not as a clock would tell the time of day. The office of a steam gauge is to enable you to read the pressure on your boiler at all times, the same as a scale will enable you to determine the weight of any object.

As this is the duty of the steam gauge, it is necessary that it be absolutely correct. By the use of an unreliable gauge you may become thoroughly bewildered, and in reality know nothing of what pressure you are carrying.

This will occur in about this way: Your steam gauge becomes weak, and if your safety is set at 100 pounds, it will show 100 or even more before the pop allows the

steam to escape; or if the gauge becomes clogged, the pop may blow off when the gauge only shows 90 pounds or less. This latter is really more dangerous than the former. As you would most naturally conclude that your safety was getting weak, and about the first thing you would do would be to screw it down so that the gauge would show 100 before the pop would blow off, when in fact you would have 110 or more.

So you can see at once how important it is that your gauge and safety should work exactly together, and there is but one way to make certain of this, and that is to test your steam gauge. If you know the steam gauge is correct, you can make your safety valve agree with it; but never try to make it do so until you know the gauge is reliable.

HOW TO TEST A STEAM GAUGE

Remove it from the boiler and take it to some shop where there is a steam boiler in active use; have the engineer attach your gauge where it will receive the direct steam pressure, and if it shows the same as his gauge, it is reasonable to suppose that your gauge is correct. If the engineer to whom you take your gauge should say he thinks his gauge is weak, or a little strong, then go somewhere else. I have already told you that I did not want you to guess at anything about your engine—I want you

to know it. However, should you find that your gauge shows, when tested with another gauge, that it is weak or unreliable in any way, you should repair it at once, and the safest way is to get a new one, and yet I would advise you first to examine it and see if you cannot discover the trouble. It frequently happens that the pointer becomes loosened on the journal or spindle, which attaches it to the mechanism that operates it. If this is the trouble, it may be easily remedied, but should the trouble prove to be in the spring, or in the delicate interior mechanism, it would be much more satisfactory to get a new gauge.

In selecting a new gauge you will be better satisfied with a gauge having a double spring or tube, as they are less liable to freeze or become strained from a high pressure, and the double spring will not allow the needle or pointer to vibrate when subject to a shock or sudden increase of pressure, as with the single spring. A careful engineer will have nothing to do with a defective steam gauge or an unreliable safety valve. Some steam gauges are provided with a seal, and as long as this seal is not broken the factory will make it good.

FUSIBLE PLUG

We have told you about a safety valve, and now we will have something to say about safety plugs. A safety,

or fusible plug, is a hollow brass plug or bolt, screwed into the crown sheet or top of the fire box. The hole through the plug is filled with some soft metal that will fuse at a much less temperature than is required to burn iron. The heat from the firebox will have no effect on this fusible plug as long as the crown sheet is covered with water, but the moment the water level falls below the top of the crown sheet, thereby exposing the plug, this soft metal is melted and runs out. This allows the steam to rush down through the opening in the plug, puts out the fire and prevents any injury to the boiler. All this sounds very fine, but I am free to confess that I am not an advocate of a fusible plug. After telling you to never allow the water to get low, and then to say there is something to make even this allowable, sounds very much like the preacher who told his boy "never go fishing on Sunday, but if you do go, to be sure and bring home the fish." I would have no objejction to the safety plug if the engineer did not know it was there. I am aware that some states require that all engines be fitted with a fusible plug. I do not question their good intentions, but I do question their judgment. It seems to me they are granting a license to carelessness. For instance, an engineer is running with a low gauge of water, owing possibly to the tanks being delayed longer than usual. He knows the water is getting low, but he says to himself, "well, if the water gets too low I will only blow out the plug," and so

he continues to run until the tank arrives. If the plug holds, he at once begins to pump in cold water, and most likely does it on a very hot sheet, which of itself, is something he never should do. If the plug does blow out he is delayed a couple of hours at least, before he can put in a new plug and get up steam again. Now suppose he had not had a soft plug (as they are sometimes called), he would not even have had a hot crown sheet, and would only have lost the time he waited on the tank. This is not a fancied circumstance by any means, for it happens every day. The engineer running an engine with a safety plug seldom stops for a load of water until he blows out the plug. It frequently happens that a fusible plug becomes corroded to such an extent that it will stand a heat sufficient to burn the iron. This is my greatest objection to it. The engineer continues to rely on it for safety, the same as if it were in perfect order, and the ultimate result is he burns or cracks his crown sheet. I have already stated that I have no objection to the plug, if the engineer did not know it was there, so if you must use one, attend to it, and every time you clean your boiler scrape the upper or water end of the plug with a knife, and be careful to remove any corrosive matter that may have collected on it, and then treat your boiler exactly as though there was no such a thing as a safety plug in it. A safety plug was not designed to let you run with any lower gauge of water. It is placed there to prevent

injury to the boiler, in case of an accident or when, by some means, you might be deceived in your gauge of water, if by mistake, a fire was started without much water in the boiler.

Should the plug melt out, it is necessary to replace it at once, or as soon as the heat will permit you to do so. It might be a saving of time to have an extra plug always ready, then all you have to do is to remove the melted one by unscrewing it from the crown sheet and screwing the extra one in. But if you have no extra plug you must remove the first one and refill it with babbitt. You can do this by filling one end of the plug with wet clay and pouring the metal into the other end, and then pounding it down smooth to prevent any leaking. This done, you can screw the plug back into its place.

If you should have two plugs, as soon as you have melted out one replace it with the new one, and refill the other at your earliest convenience. By the time you have replaced a fusible plug a few times in a hot boiler you will conclude it is better to keep water over your crown sheet.

LEAKY FLUES

What makes flues leak? I asked this question once, and the answer was that the flues were not large enough to fill up the hole in the flue sheet. This struck me

as being funny at first, but on second thought I concluded it was about correct. Flues may leak from several causes, but usually it can be traced to the carelessness of some one. You may have noticed by this time that I am inclined to blame a great many things to carelessness. Well, by the time you have run an engine a year or two you will conclude that I am not unjust in my suspicions. I do not blame engineers for everything, but I do say that they are responsible for a great many things which they endeavor to shift onto the manufacturer. If the flues in a new boiler leak, it is evident that they were slighted by the boiler-maker; but should they run a season or part of a season before leaking, then it would indicate that the boiler-maker did his duty, but the engineer did not do his. He has been building too hot a fire to begin with, or has been letting his fire door stand open; or he may have overtaxed his boiler; or else he has been blowing out his boiler when too hot; or has at some time blown out with some fire in the firebox. Now, any one of these things, repeated a few times, will make the best tubes leak. You have been advised already not to do these things, and if you do them, or any of them, I want to know what better word there is to express it than "carelessness."

There are other things that will make your flues leak. Pumping cold water into a boiler with a low gauge of water will do it, if it does nothing more serious. Pour-

ing cold water into a hot boiler will do it. For instance, blowing out a boiler while in the field, and then refilling before the iron has time to get cool. I have seen an engineer pour water into a boiler as soon as the escaping steam would admit. The flues cannot stand such treatment, as they are thinner than the shell or flue sheet, and therefore cool much quicker, and in contracting are drawn from the flue sheet, and as a matter of course begin to leak. A flue, when once started to leak, seldom stops without being set up, and one leaky flue will start others, and what are you going to do about it? Are you going to send to a boiler shop and get a boilermaker to come out and fix them and pay him from forty to sixty cents an hour for doing it? I don't know but that you must the first time, but if you are going to make a business of making your flues leak, you had best learn how to repair them yourself. You can do it if you are not too big to get into the fire door. You should provide yourself with a flue expander, a calking tool, and a machinist's hammer (not too heavy). Take into the firebox with you a piece of clean waste with which you will wipe off the ends of the flues and flue sheet to remove any soot or ashes that may have collected around them. After this is done you will force the expander into the flues, driving it well up, in order to bring the shoulder of the expander up snug against the head of the flue. Then drive the tapering pin into the expander. By driving the pin in

too far you may spread the flue sufficient to crack it, or you are more liable, by expanding too hard, to spread the hole in the flue sheet and thereby loosen other flues. You must be careful about this. When you think you have expanded sufficiently, hit the pin a side blow in order to loosen it, and turn the expander about one-quarter of a turn, and drive it up as before. Repeat this operation until you have made the entire circle of flues. Then remove the expander, and you are ready for your beader or calking tool. It is best to expand all the flues that are leaking before beginning with the beader.

The beader is used by placing the gauge or guide end within the flue, and with your light hammer the flue can be calked or beaded down against the flue sheet. Be careful to use your hammer lightly, so as not to bruise the flues or sheet. When you have gone over all the expanded flues in this way, you will, if you have been careful, have a good job. A little practice, and you will become quite an expert. I never saw a man go into a firebox and stop the leak but that he came out well pleased with himself. The fact that a firebox is no pleasant workshop may have had something to do with it. If your flues have been leaking badly, and you have expanded them, it would be well to test your boiler with cold water pressure to make sure that you have a good job.

How are you going to test your boiler? If you can attach to a hydrant, do so, and when you have given your

boiler all the pressure you want, you can then examine your flues carefully, and should you find any seeping of water, you can use your beader lightly until such leaks are stopped. If the waterworks will not afford you sufficient pressure, you can bring it up to the required pressure by attaching a good hand force pump.

In testing for the purpose of ascertaining if you have a good job on your flues, it is not necessary to put on any greater cold water pressure than you are in the habit of carrying. For instance, if your safety valve is set at one hundred and ten pounds, this pressure of cold water will be sufficient to test the flues.

Now, suppose you are out in the field and want to test your flues. Of course, you have no hydrant to attach to, and you happen not to have a force pump, it would seem you were in bad shape to test your boiler with cold water. Well, you can do it by proceeding in this way: When you have expanded and beaded all the flues that were leaking, you will then close the throttle tight, take off the safety valve (as this is generally attached at the highest point) and fill the boiler full. It is absolutely necessary that all the space in the boiler should be filled with cold water. Then screw the safety valve back in its place. You will then get back in the firebox with your tools and have someone place a small sheaf of wheat or oat straw under the firebox or under waist of boiler if open firebox, and set fire to it. The expansive force of the water

caused by the heat from the burning straw will produce the pressure desired. You should know, however, that your safety is in perfect order. When the water begins to escape at the safety valve, you can readily see if you have expanded your flues sufficiently to keep them from leaking.

This makes a very nice and steady pressure, and although the pressure is caused by heat, it is a cold water pressure, as the water is not heated beyond one or two degrees. This mode of testing, however, cannot be applied in very cold weather, as water has no expansive force within a range of five degrees around the freezing point.

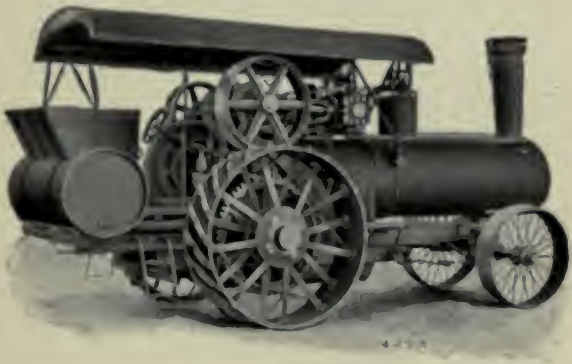
These tests, however, are only for the purpose of trying your flues and are not intended to ascertain the efficiency or strength of your boiler. When this is required, I would advise you to get an expert to do it, as the best test for this is the hammer test, and only an expert should attempt it.

PART FIVE.

Any young engineer who will make use of what he has read will never get his engine into much trouble. Manufacturers of farm engines today make a specialty of this class of goods, and they endeavor to build them as simple and with as few parts as possible. They do this knowing that, as a rule, they must be run by men who cannot take a course in practical engineering. If each one of the many thousands of engines that are turned out every year required a practical engineer to run it, it would be better to be an engineer than to own an engine. Manufacturers knowing this, therefore make their engines as simple and with as little liability to get out of order as possible. The simplest form of an engine, however, requires of the operator a certain amount of brains and a willingness to do that which he knows should be done. If you, who read this, will follow the instructions you have already received, you can run your engine as successfuly as any one can wish as long as your engine is in order, and, as I have just stated, it is not liable to get out of order, except from constant wear, and this wear will appear in the boxes, journals and valves.

The brasses on the wrist pin and cross-head will probably require your first and most careful attention, and of these two the wrist or crank box will require the most; since what is true of one box is true of boxes in general. It is, therefore, not necessary to consider all boxes in instructing you how to handle them. We will take up the box most likely to require your attention. This is the wrist box. You will find this box in two parts or halves. In a new engine you will find that these two halves do not meet on the wrist pin by at least one-eighth of an inch. They are brought up to the pin by means of a wedge-shaped key. (I am speaking now of the most common form of wrist boxes. If your engine should not have this key, it will have something which serves the same purpose.) As the brasses wear you can take up this wear by forcing the key down, which brings the two halves nearer together. You can continue to gradually take up this wear until you have brought them together. You will then see that it is necessary to do something, in order to take up any more wear, and this "something" is to take out the brasses and file about one-sixteenth of an inch off from the edge of each brass. This will allow you another eighth of an inch to take up in wear.

Now here is a nice little problem for you to solve and I want you to solve it to your own satisfaction, and when you do, you will thoroughly understand it, and to understand it is to never allow it to get you into trouble. We



THE ECLIPSE ENGINE

One of the pleasures we get out of life is to compliment men and things deserving of same.

The Frick Eclipse engine shown here is one of the things deserving of such compliments, and to list it among the standards is a pleasure.

Get their catalogue and note their special features. Their line is complete.

See article on Standard Engines, Page 119.

started out by saying that in a new engine you would most likely find about one-eighth of an inch between the brasses, and we said you would finally get these brasses, or halves together, and would have to take them out and file them. Now we have taken up one-eighth of an inch and the result is, we have lengthened our pitman just one-sixteenth of an inch; or in other words, the center of the wrist pin and the center of the cross-head are just one-sixteenth of an inch further apart than they were before any wear had taken place, and the piston head has one-sixteenth of an inch more clearance at one end, and one-sixteenth of an inch less at the other end than it had before. Now if we take out the boxes and file them so we have another eighth of an inch, by the time we have taken up this wear, we will then have this distance doubled, and we will soon have the piston head striking the end of the cylinder, and besides, the engine will not run as smooth as it did. Half of the wear comes off of each half, and the half next to the key is brought up to the wrist pin because of the tapering key, while the outside half remains in one place. You must therefore place back of this half a thin piece of sheet copper, or a piece of tin. Now suppose our boxes had one-eighth of an inch for wear. When we have taken up this much we must put in one-sixteenth of an inch backing (as it is called). for we have reduced the outside half by just that amount. We have also reduced the front or inside half the same,

but as we have said, the tapering key brings this half up to its place.

Now we think we have made this clear enough and we will leave this and go back to the key again. You must remember that we stated that the key was tapering or a wedged shape. Since a wedge is equally as powerful as a screw you must bear in mind that a slight tap will bring these two boxes up tight against the wrist pin. Young engineers experience more trouble with this box than with any other part of the engine, and all because they do not know how to manage it. You should be very careful not to get your box too tight, and don't imagine that every time there is a little knock about your engine you can stop it by driving the key down a little more. This is a great mistake that many, and even old engineers make. I at one time saw a wrist pin and boxes ruined by the engineering trying to stop a knock that came from a loose fly-wheel. It is a fact, and one that has never been satisfactorily explained, that a knock coming from almost any part of an engine will appear to be in the wrist. So bear this in mind and don't allow yourself to be deceived in this way, and never try to stop a knock until you have first located the trouble beyond a doubt.

When it becomes necessary to key up your brasses, you will find it a good safe way to loosen up the set screw which holds the key, then drive it down till you are satisfied you have it tight. Then drive it back again and

then with your fist drive the key down as far as you can. You may consider this a peculiar kind of a hammer, but your boxes will rarely ever heat after being keyed in this manner.

KNOCK IN ENGINES

What makes an engine knock or pound? A loose pillow block box is a good "knocker." The pillow block is a box next to the crank or disc wheel. This box is usually fitted with set bolts and jamb nuts. You must also be careful not to set this up too tight, remembering always that a box when too tight begins to heat and this expands the journal, causing greater friction. A slight turn of a set bolt one way or the other may be sufficient to cool a box that may be running hot, or to heat one that may be running cool. A hot box from neglect of oiling can be cooled by supplying oil, provided it has not already comenced to cut. If it shows any sign of cutting, the only safe way is to remove the box and clean it thoroughly.

Loose eccentric yokes will make a knock in an engine, and it may appear to be in the wrist. You will find packing between the two halves of the yoke. Take out a thin sheet of this packing, but don't take out too much, as you are liable then to get them too tight and they may stick and cause your eccentrics to slip. We will have more to say about the slipping of the eccentrics later on.

If the piston rod is loose in the cross-head it will make

a knock, which also appears in the wrist. Tighten the piston and you will stop it. The piston rod may be keyed in the cross-head, or it may be held in place by a nut. The key is less liable to get loose, but should it work loose a few times it may be necessary to replace it with a new one. And this is one of the things that cause a bad break when it works out or gets loose. If it gets loose it may not come out, but it will not stand the strain very long in this condition, and will break, allowing the piston to come out of the cross-head, and you are certain to knock out one cylinder head and possibly both of them. The nut will do the same thing if allowed to come off. So this is one of the connections that will claim your attention once in a while, but if you train your ear to detect any unusual noise you will discover it as soon as it gives the least in either key or nut.

The cross-head loose in the guides will cause a knock. If the cross-head is not provided for taking up this wear, you can take off the guides and file them enough to allow them to come up to the cross-head, but it is much better to have them planed off, which insures the guides coming up square against the cross-head and thus prevent any heating or cutting.

A knock caused by a loose fly-wheel will most likely puzzle you more than anything else. So remember this, the wheel may apparently be tight, but should the key be the least bit narrow for the groove in the shaft, it

will make your engine bump very similar to that caused by too much or too little "lead." The only remedy for a wheel of this kind is to have a new key made, and be certain that the new key fits the key seat in both the wheel and shaft.

LEAD

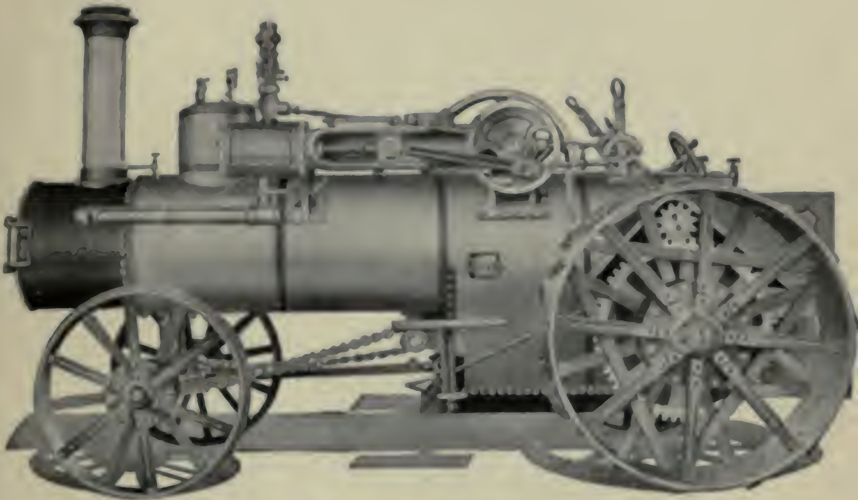
What is lead? Lead is space or opening between the valve and the edge of the port on the steam end of cylinder when the engine is on dead center. (Dead center is the two points of disc or crank wheel at which the crank pin is in direct line with piston and at which no amount of steam will start the engine.) Different makes of engines differ to such an extent that it is impossible to give any rule or any definite amount of lead for an engine. For instance, an engine with a port six inches long and one-half inch wide would require much less lead than one with a port four inches long and one inch wide. Suppose I should say one-sixteenth of an inch was the proper lead. In one engine you would have an opening one-sixteenth of an inch wide and six inches long and in the other you would have one one-sixteenth of an inch wide and four inches long; so you can readily see that it is impossible to give the amount of lead for an engine without knowing the piston area, length of port, speed, etc. Lead allows live steam to enter the cylinder just ahead of the piston at the point of finishing the stroke, and forms a "cushion," and en-

ables the engine to pass the center without a jar. Too much lead is a source of weakness to an engine, as it allows the steam to enter the cylinder too soon and forms a back pressure and tends to prevent the engine from passing the center. It will, therefore, make your engine bump, and make it very difficult to hold the packing in the stuffing box.

Insufficient lead will not allow enough steam to enter the cylinder ahead of piston to afford cushion enough to stop the inertia, and the result will be that your engine will pound on the wrist pin. You most likely have concluded by this time that "lead" is no small factor in the smooth running of an engine, and you, as a matter of course, will want to know how you are to obtain the proper lead. Well, don't worry yourself. Your engine is not going to have too much lead today and not enough tomorrow. If your engine was properly set up in the first place the lead will be all right, and continue to be right as long as the valve is not disturbed from its original position. This brings us to the most important duty of an engineer as far as the engine is concerned, viz.: Setting the Valve.

SETTING A VALVE

The proper and accurate setting of a valve on a steam engine is one of the most important duties that you will have to perform, as it requires a nicety of calculation and



WOOD BROS. ENGINE

There is beauty in the lines of a well proportioned engine, as well as in that of well bred stock, and the practical engineer, on seeing the above engine will readily comprehend my meaning. It is manufactured by the Wood Bros. Steel Self-Feeder Co., Des Moines, Iowa, who build a full line of engines, threshers, feeders, engine tenders, etc. Standards every one.

See article on Standard Engines, Page 119.

mechanical accuracy. And when we remember also that this is another one of the things for which no uniform rule can be adopted, owing to the many circumstances which go to make an engine so different under different conditions, we find it very difficult to give you the light on this part of your duty which we would wish to. We, however, hope to make it so clear to you that by the aid of the engine before you, you can readily understand the conditions and principles which control the valve in the particular engine which you may have under your management.

The power and economy of an engine depends largely on the accurate operation of its valve. It is, therefore, necessary that you know how to reset it, should it become necessary to do so.

An authority says, "Bring your engine to a dead center and then adjust your valve to the proper lead." This is all right as far as it goes, but how are you to find the dead center? I know that it is a common custom in the field to bring the engine to a center by the use of the eye. You may have a good eye, but it is not good enough to depend on for the accurate setting of a valve.

HOW TO FIND THE DEAD CENTER

First, provide yourself with a "tram." This you can do by taking a ¼ inch iron rod, about 18 inches long,

and bend about two inches of one end to a sharp angle. Then sharpen both ends to a nice sharp point. Now, fasten securely a block of hard wood somewhere near the face of the fly wheel, so that when the straight end of your tram is placed at a definite point in the block the other, or hook end, will reach the crown of the fly wheel.

Be certain that the block cannot move from its place, and be careful to place the tram at exactly the same point on the block at each time you bring the tram into use. You are now ready to proceed to find the dead center, and in doing this remember to turn the fly wheel always in the same direction. Now, turn your engine over till it nears one of the centers, but not quite to it. You will then, by the aid of a straight-edge, make a clear and distinct mark across the guides and cross-head. Now, go around to the fly wheel and place the straight end of the tram on the same point on the block, and with the hook end make a mark across the crown or center of face of fly wheel; now turn your engine past the center and on to the point at which the line on cross-head is exactly in line with the lines on guides. Again, place your tram in the same place as before, and make another mark across the crown of fly wheel. By the use of dividers find the exact center between the two marks made on fly wheel and mark this point with a center punch. Now, bring the fly wheel to the point at which the tram, when placed at its proper place on block, the hook end, or point, will

touch this punch mark, and you will have one of the exact dead centers.

Now, turn the engine over till it nears the other center, and proceed exactly as before, remembering always to place the straight end of tram exactly in same place in block, and you will find both dead centers as accurately as if you had all the fine tools of an engine builder.

You are now ready to proceed with the setting of your valve, and as you have both dead centers to work from, you ought to be able to do it, as you do not have to depend on your eye to find them, and by the use of the tram you turn your engine to exactly the same point every time you wish to get a center.

Remove the cap on the steam chest, place your engine on dead center and give your valve the necessary amount of lead on the steam end. Now, we have already stated that we could not give you the proper amount of lead for an engine. It is presumed that the maker of your engine knew the amount best adapted to this engine, and you can ascertain his idea of this by first allowing, we will say, about one-sixteenth of an inch. Next bring your engine to the other center, and if the other end has less than one-sixteenth, then you must conclude that he intended to allow less than one-sixteenth, but should it show more than this, it is evident that he intended more than one-sixteenth lead; but in either case you must adjust your valve so as to divide the space, in order to secure

the same lead when on either center. In the absence of any better tool to ascertain if the lead is the same, make a tapering wooden wedge of soft wood, turn the engine to a center and force the wedge into the opening made by the valve hard enough to mark the wood; then turn to the next center, and if the wedge enters the same distance, you are correct; if not, adjust till it does, and when you have it set at the proper place you had best mark it by taking a sharp cold chisel and place it so that it will cut into the hub of the eccentric and in the shaft; then hit it a smart blow with a hammer. This should be done after you have set the set screws in the eccentric down solid on the shaft. Then, at any time should your eccentric slip, you have only to bring it back to the chisel mark and fasten it, and you are ready to go ahead again.

This is for a plain or single eccentric engine. A double or reversible engine, however, is somewhat more difficult to handle in setting the valve. Not that the valve itself is any different from a plain engine, but from the fact that the link may confuse you, and while the link may be in position to run the engine one way you may be endeavoring to set the valve to run it the other way.

The proper way to proceed with this kind of an engine is to bring the reverse lever to a position to run the engine forward, then proceed to set your valve the same

as on a plain engine. When you have it at the proper place, tighten just enough to keep from slipping, then bring your revese lever to the reverse position and bring your engine to the center. If it shows the same lead for the reverse motion you are then ready to tighten your eccentrics securely, and they should be marked as before.

You may imagine that you will have this to do often. Well don't be scared about it. You may run an engine a long time, and never have to set a valve. I have heard these windy engineers (you have seen them), say that they had to go and set Mr. A's or Mr. B's valve, when the facts were, if they did anything, it was simply to bring the eccentrics back to their original position. They happened to know that most all engines are plainly marked at the factory, and all there was to do was to bring the eccentrics back to these marks and fasten them, and the valve was set. The slipping of the eccentrics is about the only cause for a valve's working badly. You should therefore keep all grease and dirt away from these marks; keep the set screws well tightened, and notice them frequently to see that they do not slip. Should they slip a one-sixteenth part of an inch, a well educated ear can detect it in the exhaust. Should they slip a part of a turn as they will some times, the engine may stop instantly, or it may cut a few peculiar circles for a minute or two, but don't get excited, look to the eccentrics at once for the trouble.

Your engine may, however, act very queerly some

times and you may find the eccentrics in their proper place. Then you must go into the steam chest for the trouble. The valves in different engines are fastened on the valve rod in different ways. Some are held in place by jamb nuts, and a nut may have worked loose, causing lost motion on the valve. This will make your engine work badly. Other engines hold their valve by a clamp and pin. This pin may work out, and when it does, your engine will stop, very quickly too.

If you thoroughly understand the working of the steam, you can readily detect any defect in your cylinder or steam chest, by the use of your cylinder cocks. Suppose we try them once. Turn your engine on the forward center, now open the cocks and give the engine the steam pressure. If the steam blows out at the forward cock we know that we have sufficient lead. Now turn back to the back center, and give it steam again; if it blows out the same at this cock, we can conclude that our valve is in its proper position. Now reverse the engine and do the same thing; if the cocks act the same, we know we are right. Suppose the steam blows out of one cock all right and when we bring the engine to the other center no steam escapes from this cock, then we know that something is wrong with the valve, and if the eccentrics are in their proper position the trouble must be in the steam chest. If we open it up we will find the valve has become loosened on the rod. Again suppose we

put the engine on center, and on giving it steam, we find the steam blowing out at both cocks.

Now what is the trouble, for no engine in perfect shape will allow the steam to blow out of both cocks at the same time. It is one of two things, and it is difficult to tell. Either the cylinder rings leak and allow the steam to blow through, or else the valve is cut on the seat, and allows the steam to blow over. Either of these two causes is bad, as it not only weakens your engine, but causes a great waste of fuel and water. The way to determine which of the two causes this is to take off the cylinder head, turn engine on forward center and open throttle slightly. If the steam is seen to blow out of the port at open end of cylinder, then the trouble is in the valve, but if not, you will see it blowing through from forward end of cylinder, and the trouble is in the cylinder rings.

What is the remedy? Well, if the "rings" are the trouble, a new set will most likely remedy it should they be of the automatic or self-setting pattern, but should they be of the spring or adjusting pattern, you can take out the head and set the rings out to stop this blowing. As most all engines now are using the self-setting rings, you will most likely require a new set.

If the trouble is in the valve or steam chest, you had best take it off and have the valve seat planed down, and the valve seated to it. This is the safest and best way.

Never attempt to dress a valve down, you are most certain to make a bad job of it.

And yet I don't like the idea of advising you not to do a thing that can be done, for I do like an engineer who does not run to the shop for every little trouble. However, unless you have the proper tools you had best not attempt it. The only safe way is to scrape them down, for if your valve is cut, you will find the valve seat is cut equally as bad, and they must both be scraped to a perfect fit. Provide yourself with a piece of flat steel, very hard, 3x4 inches by about 1/8 inch, with a perfectly straight edge. With this scrape the valve and seat to a perfectly flat surface. It will be a slower process than scraping wood with a piece of glass, but you can do it. Never use a chisel or a file on a valve.

LUBRICATING OIL

What is oil?

Oil is a coating for a journal, or in other words is a lining between bearings.

Did you ever stop long enough to ask yourself the question? I doubt it. A great many people buy something to use on their engine, because it is called oil. Now if the object in using oil is to keep a lining between the bearings, is it not reasonable that you use something that will adhere to that which it is to line or cover?

Gasoline will cover a journal for a minute or two, and

oil a grade better would last a few minutes longer. Still another grade would do some better. Now if you are running your own engine, buy the best oil you can buy. You will find it very poor economy to buy cheap oil, and if you are not posted, you may pay price enough, but get a very poor article.

If you are running an engine for some one else, make it part of your contract that you are furnished with a good oil. You can not keep an engine in good shape with a cheap oil. You say "you are going to keep your engine clean and bright," but that is impossible if you must use a poor oil.

Poor oil is largely responsible for the fast going out of use of the link reverse among the makers of traction engines. While I think it very doubtful if this "reverse motion" can be equalled by any of the late devices, its construction is such as to require the best grade of cylinder oil, and without this it is very unsatisfactory (not because the valves of other valve-motions will do with a poorer grade of oil), but because its construction is such that as soon as the valve becomes dry it causes the link to jump and pound, and very soon requires repairing. While the construction of various other devices are such, that while the valve may be equally as dry it does not show the want of oil so clearly as the old style link. Yet as a matter of fact I care not what the valve-motion may be, it requires a good grade of oil.

You may ask "how am I to know when I am getting a good grade of oil?" The best way is to ascertain a good brand of oil, then use that and nothing else.

We are not selling oil, or advertising oil. However, before I get through I propose to give you the name of a good brand of cylinder oil, a good engine oil as well as good articles of various attachments, which cut no small figure in the success you may have in running an engine.

It is not an uncommon thing for an engineer (I don't like to call him an engineer either) to fill his sight-feed lubricator with ordinary engine oil, and then wonder why his cylinder squeaks. The reason is that this grade of oil cannot stand the heat in the cylinder or steam chest.

If you are carrying 90 pounds of steam you have about 320 degrees of heat in your cylinder, with 120 to 125 pounds you will have about 350 degrees of heat, and in order to lubricate your valve and valve-seat, and also the cylinder surface, you must use an oil that will not only stand this heat but considerably more so that it will have some staying qualities.

Then if you are using a good quality of oil and your link or reverse begins to knock, it is because some part of it wants attention, and you must look after it. And here is where I want to insist that you teach your ear to be your guide. You ought to be able to detect the slightest sound that is unnatural to your engine. Your eyes may be deceived, but a well trained ear can not be fooled.

I was once invited by an engineer to come out and see how nice his engine was running. I went, and found that the engine itself was running very smoothly, in fact almost noiselessly, but he looked very much disappointed when I asked him why he was doing all his work with one end of the cylinder. He asked me what I meant, and I had some difficulty in getting him to detect the difference in the exhaust of the two ends, in fact the engine was only making one exhaust to a revolution. He was one of those engineers who never discovered anything wrong until he could see it. Did you know that there are people in the world whose mental capacity can only grasp one idea at a time? That is when their minds are on any one object or principle they can not see or observe anything else. That was the case with this engineer, his mind had been thoroughly occupied in getting all the reciprocating (moving) parts perfectly adjusted, and if the exhaust had made all sorts of peculiar noises, he would not have discovered it.

The one idea man will not make a successful engineer. The good engineer can stand by and at a glance take in the entire engine, from the tank to the top of the smoke stack. He has the faculty of noting mentally, what he sees, and what he hears, and by combining the results of the two, he is enabled to size up the condition of the engine at a glance. This, however, only comes with experi-

ence, and verges on expertness. And if you wish to be an expert, learn to be observing.

It is getting very common among engineers to use "hard grease" on the crank pin and main journals, and it will very soon be used exclusively. With a good grade of grease your crank will not heat so quickly as with oil and your engine will be much easier to keep clean. If you are going to be an engineer be a neat one, keep your engine clean and keep yourself clean. You say you can't do that; but you can at least keep yourself looking respectably. You will most certainly keep your engine looking as though it had an engineer. Keep a good bunch of waste handy, and when it is necessary to wipe your hands use the waste and not your overalls, and when you go in to a nice dinner the cook will not say after you go out, "Look here where that dirty engineer sat." Now boys, these are things worth heeding. I have actually known threshing crews to lose good customers simply because of their dirty clothes. The women kicked and they had a right to kick. Of course, you are not expected to wear a shirt waist or knee pants, but you ought to take some pride in your personal appearance. A dirty, greasy pair of overalls is no sign of an engineer, and again these same old greasy overalls are nothing to be ashamed of, but it is a very easy matter to slip them off before going into a clean house. Suppose the entire crew of a threshing outfit should make it a rule to remove their

dirty clothes before going into a house; don't you think the old man would have a hard time persuading the women of the house to allow him to get some other crew to thresh for him the next fall?

It is not any part of my business to dictate to a threshing crew, but it is my duty to put the engineer onto anything that will be to his advantage, and cleanliness is one of the things that will be to his advantage. If you are running your own engine, you will find it pays in a business sense. If you are running an engine for some one else, this habit you will find will class you among the best engineers.

An engineer who keeps himself as clean as he can, keeps his engine as clean as he can; and while a *good* engineer does not always have a clean engine, a clean engine always has a *good* engineer. Do you see the point? But to return to hard grease and suitable cups for same.

In attaching these grease cups on boxes not previously arranged for them, it would be well for you to know how to do it properly. You will remove the journal, take a gouge and cut a clean groove across the box, starting in at one corner, about ⅛ of an inch from the point of box and cut diagonally across, coming out at the opposite corner on the other end of box. Then start at the opposite corner and run through as before, crossing the first groove in the center of box. Groove both halves of box the same, being careful not to cut out at either end,

as this will allow the grease to escape from the box and cause unnecessary waste. The shimming or packing in the box should be cut so as to touch the journal at both ends of the box, but not in the center or between these two points. So, when the top box is brought down tight, this will form another reservoir for the grease. If the box is not tapped directly in the center for the cup, it will be necessary to cut other grooves from where it is tapped into the grooves already made. A box prepared in this way will require but little attention if you use good grease.

A HOT BOX

You will sometimes get a hot box. What is the best remedy? Well, I might name you a dozen, and if I did you would most likely never have one on hand when it was wanted. So I will only give you one, and that is white lead and oil, and I want you to provide yourself with a can of this useful article. And should a journal or box get hot on your hands and refuse to cool with the usual methods, remove the cap, and after mixing a portion of the lead with oil, put a heavy coat of it on the journal, put back the cap and your journal will cool off very quickly. Be careful to keep all grit or dust out of your can of lead. Look after this part of it yourself. It is your business.

PART SIX.

Before taking up the handling of a Traction Engine, we want to tell you of a number of things you are likely to do which you ought not to do.

Don't open the throttle too quickly, or you may throw the drive belt off. It is also more apt to raise the water and start priming.

Don't attempt to start the engine with the cylinder cocks closed, but make it a habit to open them when you stop; this will always insure your cylinder being free from water on starting.

Don't talk too much while on duty.

Don't pull the ashes out of the ash pan unless you have a bucket of water handy.

Don't start the pump when you know you have low water.

Don't let it get low.

Don't let your engine get dirty.

Don't say you can't keep it clean.

Don't leave your engine at night till you have covered it up.

Don't let the exhaust nozzle lime up, and don't allow

lime to collect where the water enters the boiler, or you may split a heater pipe or knock the top off from a check valve.

Don't leave your engine in cold weather without first draining all pipes.

Don't disconnect your engine with a leaky throttle.

Don't allow the steam to vary more than 10 to 15 pounds while at work.

Don't allow anyone to fool with your engine.

Don't try any foolish experiments on your engine.

Don't run an old boiler without first having it thoroughly tested.

Don't stop when descending a steep grade.

Don't pull through a stackyard without first closing the damper tight.

Don't pull onto a strange bridge without first examining it.

Don't run any risk on a bad bridge.

A TRACTION ENGINE ON THE ROAD

You may know all about an engine. You may be able to build one, and yet run a traction in the ditch the first jump.

It is a fact that some men never can become good operators of a traction engine, and I can't give you the reason why any more than you can tell why one man can handle a pair of horses better than another man who has

had the same advantages. And yet if you do ditch your engine a few times, don't conclude that you can never handle a traction.

If you are going to run a traction engine I would advise you to use your best efforts to become an expert at it. For the expert will hook up to his load and get out of the neighborhood while the awkward fellow is getting his engine around ready to hook up.

The expert will line up to the seperator the first time, while the other fellow will back and twist around for half an hour, and then not have a good job.

Now don't make the fatal mistake of thinking that the fellow is an expert who jumps up on his engine and jerks the throttle open and yanks it around backward and forward, reversing with a snap, and makes it stand up on its hind wheels.

If you want to be an expert you must begin with the throttle, therein lies the secret of the real expert. He feels the power of his engine through the throttle. He opens it just enough to do what he wants it to do. He therefore has complete control of his engine. The fellow who backs his engine up to the separator with an open throttle and must reverse it to keep from running into and breaking something, is running his engine on his muscle and is entitled to small pay.

The expert brings his engine back under full control, and stops it exactly where he wants it. He handles his

engine with his head and should be paid accordingly. He never makes a false move, loses no time, breaks nothing, makes no unnecessary noise, does not get the water all stirred up in the boiler, hooks up and moves out in the same quiet manner, and the onlookers think he could pull two such loads, and say he has a great engine, while the engineer of muscle would back up and jerk his engine around a half dozen times before he could make the coupling, then with a jerk and a snort he yanks the separator out of the holes, and the onlookers think he has about all he can pull.

Now these are facts, and they cannot be put too strong, and if you are going to depend on your muscle to run your engine, don't ask any more money than you would get at any other day labor.

You are not expected to become an expert all at once. Three things are essential to be able to handle a traction engine as it should be handled.

First, a thorough knowledge of the throttle. I don't mean that you should simply know how to pull it open and shut it. Any boy can do that. But I mean that you should be a good judge of the amount of power it will require to do what you may wish to do, and then give it the amount of steam that it will require and no more. To illustrate this I will give an instance.

An expert was called a long distance to see an engine

that the operator said would not pull its load over the hills he had to travel.

The first pull he had to make after the expert arrived was up the worst hill he had. When he approached the grade he threw off the governor belt, opened the throttle as wide as he could get it, and made a run for the hill. The result was, that he lifted the water and choked the engine down before he was half way up. He stepped off with the remark, "That is the way the thing does." The expert then locked the hind wheels of the separator with a timber, and without raising the pressure a pound, pulled it over the hill. He gave it just throttle enough to pull the load, and made no effort to hurry it, and still had power to spare.

A locomotive engineer makes a run for a hill in order that the momentum of his train will help carry him over. It is not so with a traction engine and its load; the momentum that you get won't push very hard.

The engineer who doesn't know how to throttle his engine never knows what it will do, and therefore has but little confidence in it; while the engineer who has a thorough knowledge of the throttle and uses it, always has power to spare and has perfect confidence in his engine. He knows exactly what he can do and what he cannot do.

The second thing for you to know is to get onto the tricks of the steering wheel. This will come to you na-

turally, and it is not necessary for me to spend much time on it. All new beginners make the mistake of turning the wheel too often. Remember this—that every extra turn to the right requires two turns to the left, and every extra turn to the left requires two more to the right; especially in this the case if your engine is fast on the road.

The third thing for you to learn, is to keep your eyes on the front wheels of your engine, and not be looking back to see if your load is coming.

In making a difficult turn you will find it very much to your advantage to go slow, as it gives you much better control of your front wheels, and it is not a bad plan for a beginner to continue to go slow till he has perfect confidence in his ability to handle the steering wheel as it may keep him out of some bad scrapes.

How about getting into a hole? Well, you are not interested half as much in knowing how to get into a hole as you are in knowing how to get out. An engineer never shows the stuff he is made of to such good advantage as when he gets into a hole; and he is sure to get there, for one of the traits of a traction engine is its natural ability to find a soft place in the ground.

Head work will get you out of a bad place quicker than all the steam you can get in the boiler. Never allow the drivers to turn without doing some good. If

you are in a hole, and you are able to turn your wheels, you are not stuck; but don't allow your wheels to slip, it only lets you in deeper. If your wheels can't get a footing, you want to give them something to hold to. Most smart engineers will tell you that the best thing is a heavy chain. That is true. So are gold dollars the best things to buy bread with, but you have not always got the gold dollars, neither have you always got the chain. Old hay or straw is a good thing; old rails or timber of any kind. The engineer with a head spends more time trying to give his wheels a hold than he does trying to pull out, while the one without a head spends more time trying to pull out than he does trying to secure a footing, and the result is, that the first fellow generally gets out at the first attempt, while the other fellow is lucky if he gets out the first half day.

If you have one wheel perfectly secure, don't spoil it by starting your engine till you have the other just as secure.

If you get into a place where your engine is unable to turn its wheels, then you are stuck, and the only thing for you to do is to lighten your load or dig out. But under all circumstances your engine should be given the benefit of your judgement.

All traction engines to be practical must of a necessity be reversible. To accomplish this, the link with the double eccentric is the one most generally used,

although various other devices are used with more or less success. As they all accomplish the same purpose it is not necessary for us to discuss the merits or demerits of either.

The main object is to enable the operator to run his engine either backward or forward at will, but the link is also a great source of economy, as it enables the engineer to use the steam more or less expansively, as he may use more or less power, and, especially is this true, while the engine is on the road, as the power required may vary in going a short distance, anywhere from nothing in going down hill, to the full power of your engine in going up.

By using steam expansively, we mean the cutting off of the steam from the cylinder, when the piston has traveled a certain part of its stroke. The earlier in the stroke this is accomplished the more benefit you get from the expansive force of the steam.

The reverse on traction engines is usually arranged to cut off at ¼, ½, or ¾. To illustrate what is meant by "cutting off" at ¼, ½, or ¾, we will suppose the engine has a 12 inch stroke. The piston begins its stroke at the end of the cylinder, and is driven by live steam through an open port, 3 inches or one quarter of the stroke, when the port is closed by the valve shutting the steam from the cylinder, and the piston is driven the remaining 9 inches of its stroke by the

expansive force of the steam. By cutting off at ½ we mean that the piston is driven half its stroke, or 6 inches, by live steam, and by the expansion of the steam the remaining 6 inches; by ¾ we mean that live steam is used 9 inches before cutting off, and expansively the remaining 3 inches of stroke.

Here is something for you to remember: "The earlier in the stroke you cut off, the greater the economy, but the less the power; the later you cut off the less the economy and the greater the power."

Suppose we go into this a little further. If you are carrying 100 pounds pressure and cut off at ¼, you can readily see the economy of fuel and water, for the steam is only allowed to enter the cylinder during ¼ of its stroke; but by reason of this, you only get an average pressure on the piston head of 59 pounds throughout the stroke. But if this is sufficient to do the work, why not take advantage of it and thereby save your fuel and water? Now, with the same pressure as before, and cutting off at ½, you have an average pressure on piston head of 84 pounds, a gain of 50 per cent in economy and a loss of 16 per cent in power. Cutting off at ¾ gives you an average pressure of 96 pounds throughout the stroke. A gain on cutting off at ¼ of 75 per cent in economy, and a loss of nearly 46 per cent in power. This shows that the most available point at which to work steam expansively is at

½, as the percentage of increase of power does not equal the percentage of loss in economy. The nearer you bring the reverse lever to center of quadrant, the earlier will the valve cut the steam and the less will be the average pressure, while the farther away from the center the latter in the stroke will the valve cut the steam, and the greater the average pressure, and consequently, the greater the power. We have seen engineers drop the reverse back in the last notch in order to make a hard pull, and were unable to tell why they did so.

Now, as far as doing the work is concerned, it is not absolutely necessary that you know this; but if you do know it, you are more likely to profit by it and thereby get the best results out of your engine. And as this is our object, we want you to know it, and be benefitted by the knowledge. Suppose you are on the road with your engine and load, and you have a stretch of nice road. You are carrying a good head of steam and running with lever back in the corner or lower notch. Now your engine will travel along at its regular speed, and say you run a mile this way and fire twice in making it. You now ought to be able to turn around and go back over the same road with one fire by simply hooking the lever up as short as it will allow to do the work. Your engine will make the same time with half the fuel and water, simply because

you utilize the expansive force of the steam instead of using the live steam from the boiler. A great many good engines are condemned and said to use too much fuel, and all because the engineer takes no pains to utilize the steam to the best advantage.

I have already advised you to carry a "high pressure;" by a high pressure I mean anywhere from 100 to 125 lbs. I have done this expecting you to use the steam expansively whenever possible, and the expansive force of steam increases very rapidly after you have reached 70 lbs. Steam at 80 lbs. used expansively will do nine times the work of steam at 25 lbs. Note the difference. Pressure 3 1-5 times greater. Work performed, 9 times greater. I give you these facts trusting that you will take advantage of them, and if your engine at 100 or 110 lbs. will do your work cutting off at ¼, don't allow it to cut off at ⅓. If cutting off at ½ will do the work, don't allow it to cut off at ¾, and the result will be that you will do the work with the least posible amount of fuel, and no one will have any reason to find fault with you or your engine.

Now we have given you the three points which are absolutely necessary to the successful handling of a traction engine. We went through it with you when running as a stationary; then we gave you the pointers to be observed when running as a traction or road

engine. We have also given you hints on economy, and if you do not already know too much to follow our advice, you can go into the field with an engine and have no fears as to the results.

How about bad bridges?

Well, a bad bridge is a bad thing, and you cannot be too careful. When you have questionable bridges to cross over, you should provide yourself with good hard wood planks. If you can have them sawed to order have them 3 inches in the center and tapering to 2 inches at the ends. You should have two of these about 16 feet long, and two 2x12 planks about 8 feet long. The short ones for culverts, and for helping with the longer ones in crossing longer bridges.

An engine should never be allowed to drop from a set of planks down onto the floor of the bridge. This is why I advocate four planks. Don't hesitate to use the plank. You had better plank a dozen bridges that don't need it than to attempt to cross one that does need it. You will also find it very convenient to carry at least 50 feet of good heavy rope. Don't attempt to pull across a doubtful bridge with the separator or tank hooked directly to the engine. It is dangerous. Here is where you want the rope. An engine should be run across a bad bridge very slowly and carefully, and not allowed to jerk. In extreme

cases it is better to run across by hand; don't do this more than once; get after the road supervisors.

SAND

An engineer wants a sufficient amount of "sand," but he don't want it in the road. However, you will find it there and it is the meanest road you will have to travel. A bad sand road requires considerable slight of hand on the part of the engineer if he wishes to pull much of a load through it. You will find it to your advantage to keep your engine as straight as possible, as you are not so liable to start one wheel to slipping any sooner than the other. Never attempt to "wiggle" through a sand bar, and don't try to hurry through; be satisfied with going slow; just so you are going. An engine will stand a certain speed through sand, and the moment you attempt to increase that speed, you break its footing, and then you are gone. In a case of this kind a few bundles of hay is about the best thing you can use under your drivers in order to get started again. But don't lose your temper; it won't help the sand any.

Now no doubt the reader wonders why I have said nothing about compound engines. Well in the first place. it is not necessary to assist you in your work, and if you can handle the single cylinder engine, you can handle the compound.

The question as to the advantage of a compound engine is, or would be an interesting one if we cared to discuss it.

The compound traction engine has come into use within the past few years, and I am inclined to think more for a sort of a novelty or talking point rather than to produce a better engine. There is no question but that there is a great advantage in the compound engine for stationary and marine engines.

In a compound engine the steam first enters the small or high pressure cylinder and is then exhausted into the larger or low pressure cylinder, where the expansive force is all obtained.

Two cylinders are used because we can get better results from high pressure in the use of two cylinders of different areas than by using but one cylinder, or simple engine.

That there is a gain in a high pressure, can be shown very easily:

For instance, 100 pounds of coal will raise a certain amount of water from 60 degrees, to 5 pounds steam pressure, and 102.9 pounds would raise the same water to 80 pounds, and 104.4 would raise it to 160 pounds, and this 160 pounds would produce a large increase of power over the 80 pounds at a very slight increase of fuel. The compound engine will furnish the same number of horse power, with less fuel than

the simple engine, but only when they are run at the full load all the time.

If, however, the load fluctuates and should the load be light for any considerable part of the day, they will waste the fuel instead of saving it as compared with the simple engine.

No engine can be subjected to more variation of loads than the traction engine, and as the above are facts the reader can draw his own conclusions.

FRICTION CLUTCH

The friction clutch is now used almost exclusively for engaging the engine with the propelling gearing of the traction drivers, and it will most likely give you more trouble than any one thing on your engine, from the fact that to be satisfactory they require a nicety of adjustment that is very difficult to attain, a half turn of the expansion bolt one way or the other may make your clutch work very nicely, or very unsatisfactory, and you can only learn this by carefully adjusting the friction shoes, until you learn just how much clearance they will stand when the lever is out, in order to hold sufficcient when the lever is thrown in. If your clutch fails to hold, or sticks, it is not the fault of the clutch, it is not adjusted properly. And you may have it correct today and tomorrow it will need readjustment, caused by the wear in the shoes;

you will have to learn the clutch by patience and experience.

But I want to say to you that the friction clutch is a source of abuse by many an engineer, because the engineer uses no judgement in its use.

A certain writer on engineering makes use of the following, and gives me credit: "Sometimes you may come to an obstacle in the road, over which your engines refuses to go, you may perhaps get over it in this way, throw the clutch-lever so as to disconnect the road wheels, let the engine get up to full speed and then throw the clutch-lever back so as to connect the road wheels." Now I don't thank anyone for giving me credit for saying any such thing. That kind of thing is the height of abuse of an engine.

I am aware that when the friction clutch first came into use, its representatives made a great talk on that sort of thing to the green buyer. But the *good engineer* knows better than to treat his engine that way.

Never attempt to pull your loads over a steep hill without being certain that your clutch is in good shape, and if you have any doubts about it put in the tight gear pin. Most all engines have both the friction and the tight gear pin. The pin is much the safer in a hilly country, and if you have learned the secret of the throttle you can handle just as big loads

with the pin as with the clutch, and will never tear your gearing off or loosen the stud bolts in the boiler. Now you will have noticed that I lay no small stress in the handling of the *throttle*.

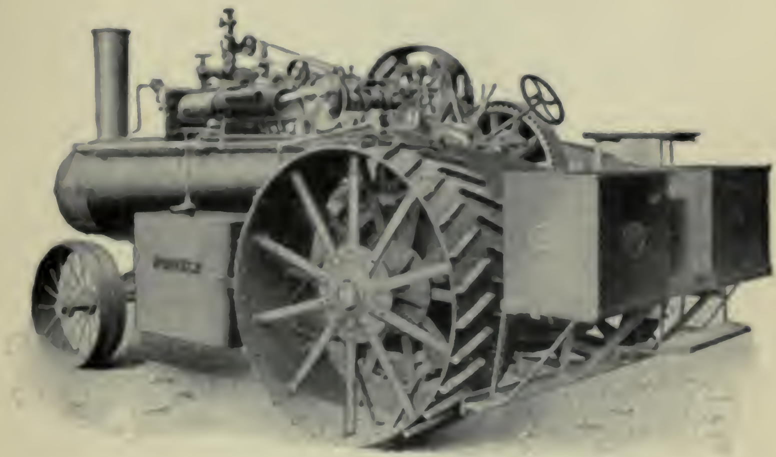
I wish I could step up on the foot board with every reader of this book who really wants to be an expert with an engine.

I have already stated that a good way to know how to do a thing is to know how not to do it. A few days ago I saw an engineer (who to my own knowledge had run his engine ten years), step up on the foot board to back his engine up a few feet to hook onto the separator. Now it was a straight back, no necessity for touching the steering wheel. The engine however was on the wrong quarter to back. So this expert (?) took hold of the steering wheel with his right hand, reversed the engine with his left hand, shifted his left to the trottle, and by this time the engine had turned to the wrong quarter and it was again necessary to reverse the engine. Back went his left hand to the reverse, threw it over, and shifted his left to the throttle again. He repeated this move four times before he moved his engine back, and all the time holding onto the steering wheel with his right hand as though it might get away.

Now that is the way not to do it. As I stated it was a straight back. The steering wheel needed no

attention, and he knew it. The way this particular engine was arranged the natural position was to take hold of the reverse lever with his left hand and the throttle with his right. This move would have enabled him to open the throttle just a fraction of a second after he had reversed and his engine would have moved back under perfect control, provided he handled his throttle as he should. You of course want to know how he should have handled it. Well, as he only wished to back a few feet, he should have opened the throttle wide, and before the engine had made a complete turn shut it off entirely. The expansive force of the steam in the cylinder steam chest and supply pipe would have carried him back a couple of feet, and another movement of the same kind would have given his engine a few more turns. Besides this position enables you to reverse your engine instantly, if necessary. You will see I advocate making the steering wheel a secondary matter or consideration. If you have perfect control over your reverse and throttle the steering wheel will never get you into trouble. You can certainly see the point in this.

But suppose your engine is cramped and you only have a limited distance to go ahead or back, and you wish to straighten up your engine. First see that your engine is in the position to go ahead or back as you desire. Take hold of the steering wheel, and with



RUMELY ENGINE

The Rumely name has been before the American threshermen and farmers fifty-seven years. It is therefore hardly necessary to introduce this as the Rumely Threshing Engine.

See their Plowing Engine on another page and article on Standard Engines, Page 119.

A RUMELY PLOWING ENGINE

The Rumely plowing engine is built to get the maximum draw-bar pull from every pound of coal and water used, and they get it.

The factory is at La Porte, Ind., where they build a complete line. They will also soon be heard from in the Gasoline line.

See their Threshing Engine on a preceding page and article on Standard Engines, Page 119.

the other hand give the engine a wide open throttle, then close it, and at the same time turn the steering wheel as rapidly as possible. When your engine has made a few turns repeat the operation of opening and closing the throttle. This is the only way to move a traction engine slowly, and by doing so you are not going to bang into something or hurt anyone. Now this is for a stiff or tight geared engine. If you are using the clutch you will handle your engine differently. If your clutch is in good shape and will not stick when you want it to let loose, and will not let loose when you want it to hold you can do very differently from what I have just advised. We will say that your clutch is in good shape. You would step on your engine and take hold as before, that is, reverse with one hand and throttle with the other, and after starting your engine in the proper direction you can shift one hand to the steering wheel and the other to the clutch lever. But unless you have perfect faith in your clutch you had best treat your engine as if it was a stiff gear, and handle it as I have already suggested. If you do you will not back into anything or pinch anyone's fingers.

Under any circumstances don't try to handle both the reverse and the throttle with one hand unless you have but one, and by the way, the writer knows a couple of good engineers with but one arm, and this

fact ought to encourage you who have two arms to handle your engine to perfection.

The double or two cylinder engine is becoming more general and while I have been careful not to recommend or condemn any particular type of engine, I will say that a naturally awkward engineer can make a much more respectable showing with the double engine, but the expert or clever engineer can show his ability and skill to much better advantage with the single engine.

Now you will find somewhere in this book that I make use of these words: "A good —— horse power engine, or a —— horse power engine in *good condition*" will do certain work.

Now what is meant by an engine in *good condition?*

In the first place an engine to be in good condition *must have a clean boiler.* The valve must be set, so as to admit an equal amount of steam at either end of the cylinder. It must not blow over, I mean by this that the valve and seat must present a perfect steam fitting surface otherwise the steam will "blow over" or pass between the valve and seat, escaping through the exhaust and your boiler will require too much water and fuel.

The rings must fit snug and close, to prevent "blow-

ing through." By blowing through is meant steam passing between the piston rings and cylinder.

This is a great source of weakness, besides a great loss of steam.

With the packing properly looked after, all bearings in good shape, you can consider your engine in "good condition." And when you experience any trouble in pulling your load, or keeping up steam with an engine that in the past was satisfactory you will find the trouble in some of the places I have mentioned.

TRANSMISSION OF POWER

The following may assist you in determining or arriving at some idea of the amount of power you are supplying with your engine.

For instance, a 1 inch belt of the standard grade with the proper tension, neither too tight nor too loose, running at a maximum speed of 800 ft. a minute will transmit one horse power; running 1600 ft., 2 horse power, and 2400 ft., 3 horse power. A 2 inch belt, at the same speed, twice the power.

Now if you know the circumference of your fly wheel, the number of revolutions your engine is making and the width of belt, you can figure very nearly the amount of power you can supply without slipping your belt. For instance, we will say your fly wheel is 40 inches in diameter or 10.5 feet nearly in circumfer-

ence and your engine is running 225 revolutions a minute; your belt will be traveling 225x10.5 feet= 2362.5 feet, or very nearly 2400 ft., and if 1 inch of belt would transmit 3 horse power running at this speed, a 6 inch belt will transmit 18 horse power; a 7 inch belt, 21 horse power; an 8 inch belt 24 horse power, and so on. With the above as a basis for figuring you can satisfy yourself as to the power you are furnishing. To get the best results a belt ought to sag slightly as it hugs the pulley closer, and will last much longer.

SOMTHING ABOUT SIGHT-FEED LUBRICATORS

All such lubricators feed oil through the drop-nipple by hydrostatic pressure; that is, the water of condensation in the condenser and its pipe being elevated above the oil magazine forces the oil out of the latter by just so much pressure as the column of water is higher than the exit or outlook of oil-nipple. The higher the column of water the more positive will be the oil feed. As soon as the oil drop leaves the nipple it ceases to be actuated by the hydrostatic pressure, and rises through the water in the sight-glass merely by the difference of its specific gravity, as compared with water, and then passes off through the ducts provided to the parts to be lubricated.

For stationary engines the double connection is preferable, and should always be connected to the live steam pipe above the throttle. The discharge arm

should always be long enough (4 to 6 inches) to insure the oil magazine and condenser from getting too hot, otherwise it will not condense fast enough to give a continuous feed of oil. For traction or road engines the single connection is used. These can be connected to live steam pipe or directly to the steam chest.

In a general way it may be stated that certain precautions must be taken to insure the satisfactory operation of all sight-feed lubricators. Use only the *best of oil,* one gallon of which is worth five gallons of cheap stuff and do far better service, as inferior grades not only clog the lubricator but choke the ducts and blur the sight-glass, etc., and the refuse of such oil will accumulate in the cylinder sufficiently to cause damage and loss of power, far exceeding the difference in cost of good oil over the cheap grades.

After attaching a lubricator, all valves should be opened wide and live steam blown through the outer vents for a few minutes to insure that the openings are clean and free. Then follow the usual directions given with all lubricators. Be particular in getting your lubricator attached so it will stand perfectly plumb, in order that the drop can pass up through the glass without touching the sides, keep the drop-nipple clean, and be particular to drain in cold weather.

Now, I am about to leave you alone with your en-

gine, just as I have left any number of young engineers after spending a day with them in the field and on the road. And I never left one that I had not already made up my mind fully as to what kind of an engineer he would make.

STANDARD ENGINES

I possibly have received more letters than there are pages in this book asking my opinion concerning certain makes of engines.

These letters contained such questions as: "Which do you consider the best engine?" "What would you advise me to buy?" etc.

Now I could not in justice to builders of standard engines answer any of these letters. Suppose I should have been interested in some one engine, I was therefore in shape to take an unfair advantage of these inquiries which were written in good faith and were entitled to an answer, but as stated above, I could not in justice to all parties concerned answer any of them. I have therefore anticipated these letters, and through the kindness of the makers of a number of standard engines am able to show them in this edition. And I can now answer these letters by saying to the readers of "Rough and Tumble," that while there are some standard engines that do not appear in this book, there are none to be found here that are not standard and up-to-date and if you are tempted to write and ask

my opinion on any particular engine, don't do it, but take it for granted that any one of the engines shown, if treated and handled as I have endeavored to show you how to treat and handle an engine, will do and be what the maker claims for it; and if you buy, or are employed to run any one of them, you will have as good as the best, and don't forget this: That when you hear an engineer condemning a standard engine or finding fault with its construction you will find that he is neither an engineer nor a mechanic.

It is true there are some good engineers who imagine they can build a better engine than the ones they run. Now this thinking so could do no harm either to the builders of the engine or himself, if he did not talk it on all occasions, for by so doing he hurts the reputation of the engine among those who are not posted on engines, and he hurts his own standing as an engineer among those who know what a good engine is.

This is only another way of saying to you, don't talk too much. If you have any spare time work off your surplus energy behind a chunk of waste, your engine will look better for it, and your reputation as an engineer will go up two points, while the same time put in talking would have let you down a few points. You would have saved the waste, but had a dirty engine. I have seen a good engineer have a dirty, greasy en-

gine. But I never saw a nice bright and clean engine have a poor engineer.

Now if you are going to buy an engine buy a standard, large enough to do your work, take some pride in it, keep it up in shape and you will never regret your choice or have any fault to find with the people who built it.

PART SEVEN.

TWO WAYS OF READING

Now there are two ways to read this book, and if I knew just how you had read it I could tell you in a minute whether to take hold of an engine or leave it alone. If you have read it one way, you are most likely to say, *"It is no trick to run an engine."* *If* you have read it the other way you will say, *"It is no* trouble to learn how to run an engine." Now this fellow will make an engineer, and will be a good one. He has read it carefully, noting the drift of my advice. Has discovered that the engineer is not expected to build an engine, or to improve it after it has been built. He has recognized the fact that the principal thing is to attend to his own business and let other people attend to theirs, and that a monkey wrench is a tool to be left in the tool box till he knows he needs it; that muscle is a good thing to have but not necessary to the successful engineer; that an engineer with a bunch of waste in his hand is a better recommendation than an "engineer's license;" that good common sense and a cool head is the very best tools

he can have. He has learned that carelessness will get him into trouble, and that to "*forget*" costs money.

Now the fellow who said, "*It is no trick to run an engine,*" read this book another way. He did not see the little points. He was hunting for big theories, scientific theories, something he could not understand, and didn't find them. He expected to find some bright scheme to prevent a boiler from exploding, and didn't notice the simple little statement, "keep water in it," that was too commonplace to notice. He was looking for cuts, diagrams, geometrical figures, theories for constructing engines and boilers and all that sort of thing and didn't find them. Hence "It is no trick to run an engine."

If this has been your idea of "Rough and Tumble Engineering" forget all about your theory, and go back and read it over and remember the little suggestions and don't expect this book to teach you how to build an engine. We didn't start out to teach you anything of the kind. That is a business of itself. A good engineer gets better money than the man who builds them. Read it as if you wanted to know how to run an engine and not how to build one.

Study the following questions and answers carefully. Don't learn them like you would a piece of poetry, but study them, see of they are practical; make yourself thoroughly acquainted with the rule of measuring

the horse-power of an engine; make yourself so familiar with it that you could figure any engine without referring to the book. Don't stop at this, learn to figure the heating surface in any boiler. It will enable you to satisfy yourself whether you are working your boiler or engine too hard or what it ought to be capable of doing.

SOME THINGS TO KNOW

Q. What is fire?

A. Fire is the rapid combustion or cunsuming of organic matter.

Q. What is water?

A. Water is a compound of oxygen and hydrogen. In weight 88 9-10 parts oxygen to 11 1-10 hydrogen. It has its maximum density at 39 degrees Fahr.. changes to steam at 212 degrees, and to ice at 32 degrees.

Q. What is smoke?

A. It is unconsumed carbon, finely divided, escaping into open air.

Q. Is excessive smoke a waste of fuel?

A. Yes.

Q. How will you prevent it?

A. Keep a thin fire, and admit cold air sufficient to insure perfect combustion.

Q. What is low water as applied to a boiler?

A. It is when the water is insufficient to cover all parts exposed to the flames.

Q. What is the first thing to do on discovering that you have low water?

A. Pull out the fire.

Q. Would it be safe to open the safety valve at such time?

A. No.

Q. Why not?

A. It would relieve the pressure on the water which being allowed to flow over the excessive hot iron would flash into steam, and might cause an explosion.

Q. Why do boilers sometimes explode just on the point of starting the engine?

A. Because starting the engine has the same effect as opening the safety valve.

Q. Are there any circumstances under which an engineer is justified in allowing the water to get low?

A. No.

Q. Why do they sometimes do it?

A. From carelessness or ignorance.

Q. May not an engineer be deceived in the guage of water?

A. Yes.

Q. Is he to be blamed under such circumstances

A. Yes.

Q. Why?

A. Because if he is deceived by it, it shows he has neglected something.

Q. What is meant by "Priming?"

A. It is the passing of water in visible quantities into the cylinder with the steam.

Q. What would you consider the first duty of an engineer on discovering that the water was foaming or priming?

A. Open the cylinder cocks at once, and throttle the steam.

Q. Why would you do this?

A. Open the cocks to enable the water to escape, and throttle the steam so that the water would settle.

Q. Is foaming the same as priming?

A. Yes and no.

Q. How do you make that out?

A. A boiler may foam without priming, but it can't prime without first foaming.

Q. Where will you first discover that the water is foaming?

A. It will appear in the glass guage, the glass will have a milky appearance and the water will seem to be running down from the top. There will be a snapping or cracking in the cylinder as quick as priming begins.

Q. What causes a boiler to foam?

A. There are a number of causes. It may come from faulty construction of the boiler; it may have insuf-

ficient steam room. It may be, and usually is, from the use of bad water, muddy or stagnant water, or water containing any soapy substance.

Q. What would you do after being bothered in this way?

A. Clean out the boiler and get better water if possible.

Q. How would you manage your pumps while the water was foaming?

A. Keep them running full.

Q. Why?

A. In order to make up for the extra amount of water going out with the steam.

Q. What is "cushion?"

A. Cushion is steam retained or admitted in front of the piston head at the finish of stroke or when the engine is on "center."

Q. What is it for?

A. It helps to overcome the "inertia" and momentum of the reciprocating parts of the engine, and enables the engine to pass the center without a jar.

Q. How would you increase the cushion in an engine?

A. By increasing the lead.

Q. What is lead?

A. It is the amount of opening the port shows on the

steam end of the cylinder when the engine is on dead center.

Q. Is there any rule for giving an engine the proper lead?

A. No.

Q. Why not?

A. Owing to their variation in construction, speed, etc.

Q. What would you consider the proper amount of lead, generally?

A. From $\frac{1}{32}$ to $\frac{1}{16}$ of an inch.

Q. What is lap?

A. It is the distance the valve overlaps the steam ports when in mid position.

Q. What is lap for?

A. In order that the steam may be worked expansively.

Q. When does expansion occur in a cylinder?

A. During the time between which the port closes and the point at which the exhaust opens.

Q. What would be the effect on an engine if the exhaust opened too soon?

A. It would greatly lessen the power of the engine.

Q. What effect would too much lead have?

A. It would also weaken the engine, as the steam would enter before the piston had reached the end of

the stroke, and would tend to prevent it passing the center.

Q. What is the stroke of an engine?

A. It is the distance the piston travels in the cylinder.

Q. How do you find the speed of a piston per minute?

A. Double the stroke and multiply it by the number of revolutions a minute. Thus an engine with a 12-inch stroke would travel 24 inches, or 2 feet, at a revolution. If it made 200 revolutions a minute, the travel of piston would be 400 feet a minute.

Q. What is considered a horse power as applied to an engine.

A. It is power sufficient to lift 33,000 pounds one foot high in one minute.

Q. What is the indicated horse power of an engine?

A. It is the actual work done by the steam in the cylinder as shown by an indicator.

Q. What is the actual horse power?

A. It is the power actually given off by the driving belt and pulley.

Q. How would you find the horse power of an engine?

A. Multiply the area of the piston by the average pressure, less 5; multiply this product by the number of

feet the piston travels per minute; divide the product by 33,000; the result will be the horse power of the engine.

Q. How will you find the area of piston?

A. Square the diameter of piston and multiply it by .7854.

Q. What do you mean by squaring the diameter?

A. Multiplying it by itself. If a cylinder is 6 inches in diameter, 36 multiplied by .7854, gives the area in square inches.

Q. What do you mean by average pressure?

A. If the pressure on boiler is 60 pounds, and the engine is cutting off at ½ stroke, the pressure for the full stroke would be 50 pounds.

Q. Why do you say less 5 pounds?

A. To allow for friction and condensation.

Q. What is the power of a 7x10 engine, running 200 revolutions, cutting off at ½ stroke with 60 pounds of steam?

A. 7x7 = 49x.7854 = 38.4846. The average pressure of 60 pounds would be 50 pounds less 5 = 45 pounds; 38.4846x45 = 1731.8070x.333 1-3 (the number of feet the piston travels per minute) = 577.269.0000 divided by 33,000 = 17½ horse power.

Q. What is a high pressure engine?

A. It is an engine using steam at a high pressure and exhausting into the open air.

Q. What is a low pressure engine?

A. It is one using steam at a low pressure and exhausting into a condenser, producing a vacuum, the piston being under steam pressure on one side and vacuum on the other.

Q. What class of engines are farm engines?

A. They are high pressure.

Q. Why?

A. They are less complicated and less expensive.

Q. What is the most economical pressure to carry on a high pressure engine?

A. From 90 to 110 pounds.

Q. Why is high pressure more economical than low pressure?

A. Because the loss is greater in low pressure owing to the atmospheric pressure. With 45 pounds steam the pressure from the atmosphere is 15 pounds, or one-third, leaving only 30 pounds of effective power; while with 90 pounds the atmospheric pressure is only one-sixth of the boiler pressure.

Q. Does it require any more fuel to carry 100 pounds than it does to carry 60 pounds?

A. It doesn't require quite as much.

Q. If that is the case why not increase the pressure beyond this and save more fuel?

A. Because we would soon pass the point of safety in a boiler, and the result would be the loss of life and property.

Q. What do you consider a safe working pressure on a boiler?

A. That depends entirely on its diameter. While a boiler of 30 inches in diameter ⅜ inch iron would carry 140 pounds, a boiler of the same thickness 80 inches in diameter would have a safe working pressure of only 50 pounds, which shows that the safe working pressure decreases very rapidly as we increase the diameter of the boiler. This is the safe working pressure for single riveted boilers of this diameter. To find the safe working pressure of a double riveted boiler of the same diameter multiply the safe pressure of the single riveted by 70, and divide by 56, this will give a safe pressure of a double riveted boiler.

Q. Why is a steel boiler superior to an iron boiler?

A. Because it is much lighter and stronger.

Q. Does boiler plate become stronger or weaker as it becomes heated?

A. It becomes tougher or stronger as it is heated, till it reaches a temperature of 550 degrees, when it rapidly decreases its power of resistance if it is heated beyond this temperature.

Q. How do you account for this?

A. Because after you pass the maximum temperature of 550 degrees, the more you raise the temperature the nearer you approach its fusing point, when its tenacity or resisting power is nothing.

Q. What is the degree of heat necessary to fuse iron?

A. 2912 degrees.

Q. Steel?

A. 2532 degrees.

Q. What class of boilers are generally used in a threshing engine?

A. The flue boiler and the tubular boiler.

Q. About what amount of heating and grate surface is required per horse power in a flue boiler?

A. About 15 square feet of heating surface and ¼ square feet of grate surface.

Q. What would you consider a fair evaporation in a flue boiler?

A. Six pounds of water to 1 pound of coal.

Q. How do these dimensions compare in a tubular boiler?

A. A tubular boiler will require ¼ less grate surface, and will evaporate about 8 pounds of water to 1 pound of coal.

Q. Which do you consider the most available?

A. The tubular boiler?

Q. Why?

A. It is the more economical and is less liable to "collapse."

Q. What do you mean by "collapse?"

A. It is a crushing in of a flue by external pressure.

Q. Is a tube of a large diameter more liable to col-

lapse than one of small diameter?

A. Yes.

Q. Why?

A. Because its power of resistance is much less than a tube of a small diameter.

Q. Is the pressure on the shell of a boiler the same as on the tubes?

A. No.

Q. What is the difference?

A. The shell of a boiler has a tearing or internal pressure while the tubes have a crushing or external pressure.

Q. What causes an explosion?

A. An explosion occurs generally from low water, allowing the iron to become overheated and thereby weakened and unable to withstand the pressure.

Q. What is a "burst?"

A. It is that which occurs when through any defect the water and steam are allowed to escape freely without further injury to boiler.

Q. What is the best way to prevent an explosion?

A. (1) Never go beyond the safe working pressure. (2) Keep the boiler clean and in good repair. (3) Keep the safety valves in good shape and the water at its proper height.

Q. What is the first thing to do on going to your engine in the morning?

A. See that the water is at its proper level.

Q. What is the proper level?

A. Up to the second gauge.

Q. When should you test or try the pop valve?

A. As soon as there is sufficient pressure.

Q. How would you start your engine after it had been standing all night?

A. Slowly.

Q. Why?

A. In order to allow the cylinder to become hot, and that the water or condensed steam may escape without injury to the cylinder.

Q. What is the last thing to do at night?

A. See that there is plenty of water in the boiler, and if the weather is cold drain all pipes.

Q. What care should be taken of the fusible plug?

A. Keep it scraped clean, and not allow it to become corroded on top.

Q. What is a fusible plug?

A. It is a hollow cast plug screwed into the crown sheet or top of fire box, and having the hollow or center filled with lead or babbitt.

Q. Is such a plug a protection to a boiler?

A. It is if kept in proper condition.

Q. Can you explain the principle of the fusible or soft plug as it is sometimes called?

A. It is placed directly over the fire, and should the water fall below the crown sheet the lead fuses or melts

and allows the steam to flow down on top of the fire, destroys the heat and prevents the burning of the crown sheet.

Q. Why don't the lead fuse with water over it?

A. Because the water absorbs the heat and prevents it reaching the fusing point.

Q. What is the fusing point of lead?

A. 618°.

Q. Is there any objection to the soft plug?

A. There is, in the hands of some engineers.

Q. Why?

A. It relieves him of the fear of a dry crown sheet, and gives him an apparent excuse for low water.

Q. Is this a real or legitimate objection?

A. It is not.

Q. What are the two distinct classes of boilers?

A. The externally and internally fired boilers.

Q. Which is the most economical?

A. The internally fired boiler.

Q. Why?

A. Because the fuel is all consumed in close contact with the sides of the furnace and the loss from radiation is less than in the externally fired.

Q. To what class does the farm or traction engine belong?

A. To the internally fired.

Q. How would you find the horse power of such a boiler?

A. Multiply *in inches* the circumference of furnace by its length, then multiply the circumference of one tube by its total length, and this product by the number of tubes, also taking into account the surface in the tube sheet, add these products together and divide by 144, this will give you the number of square feet of heating surface in the boiler. Divide this by 14 or 15, which will give the horse power of the boiler.

Q. Why do you say 14 or 15?

A. Because some claim that it requires 14 feet of heating surface to the horsepower and others 15. To give you my personal opinion I believe that any of the standard engines today with good coal and properly handled, will and are producing 1 horse power for as low as every 10 feet of surface. But to be on the safe side it is well to divide by 15 to get the horse power of your boiler, when good and bad fuel is considered.

Q. How would you find the approximate weight of a boiler by measurement?

A. Find the number of square feet in surface of boiler and fire box, and as a sheet of boiler iron or steel one-sixteenth of an inch thick, and one foot square, weighs 2.52 pounds, you should multiply the number of square feet by 2.52 and this product by the number of 16ths of

thickness of boiler sheet, and the product will approximate the weight of the boiler.

Q. What would you recognize as points in a good engineer?

A. A good engineer keeps his engine clean and washes the boiler whenever he thinks it needs it.

Never meddles with his engine, and allows no one else to do so.

Goes about his work quietly, and is always in his place, only talks when necessary, never hammers or bruises any part of his engine, allows no packing to become baked or burnt in the stuffing box or glands, renews them as quickly as they show that they require it.

Never neglects to oil, and then uses no more than is necessary.

He carries a good gauge of water and a uniform pressure of steam. He allows no unusual noise about his engine to escape his notice—he has taught his ear to be his guide.

When a job is about finished you will see him cleaning his ash pan, getting his tools together, a good fire in the fire box, in fact all ready to go, and he loses no time after the belt is thrown off. He hooks up to his load quietly, and is the first man ready to go.

*Q. When the piston head is in the exact center of the cylinder, is the engine on the quarter?

*A. It is supposed to be, but is not.

*Q. Why not?

A. The angularity of the rod prevents it reaching the quarter.

*Q. Then when the engine is on the exact quarter what position does the piston head occupy?

A. It is nearest the end next to the crank.

*Q. If this is the case, which end of the cylinder is supposed to be the stronger?

A. The opposite end, or end furthest from crank.

*Q. Why?

A. Because this end gets the benefit of the most travel, and as it makes it in the same time, it must travel faster.

*Q. At what part of the cylinder does the piston head reach the greatest speed?

A. At and near the center.

*Q. Why?

Figure this out for yourself.

Q. If you were on the road and should discover that you had low water, what would you do?

A. I would drop my load and hunt a high place for the front end of my engine, and would do it quickly, too.

Q. If by some accident the front end of your engine should drop down allowing the water to expose the crown sheet, what would you do?

**Note.—The above few questions are given for the purpose of getting you to notice the little peculiarities of the crank engine, and are not to be taken into consideration in the operation of the same.*

A. If I had a heavy and hot fire, would shovel dirt into the fire and smother it out.

Q. Why would you prefer this to drawing the fire?

A. Because it would reduce the heat at once, instead of increasing it for a few minutes while drawing out the hot bed of coals, which is a very unpleasant job.

Q. Would you ever throw water in the fire box?

A. No. It might crack the side sheets, and would most certainly start the flues.

Q. You say, in finding low water while on the road, you would run your engine with the front end on high ground. Why would you do this?

A. In order that the water would raise over the crown sheet, and thus make it safe to pump up the water.

Q. While your engine was in this shape would you not expose the front end of the flues?

A. Yes, but as the engine would not be working this would do no damage.

Q. If you were running in a hilly country how would you manage the boiler as regards water?

A. Would carry as high as the engine would allow without priming.

Q. Suppose you had a heavy load or about all you could handle, and should approach a long steep hill, what condition should the water and fire be in to give you the most advantage?

A. A moderately low gauge of water and a very hot fire.

Q. Why a moderately low gauge of water?

A. Because the engine would not be so liable to draw the water or prime in making the hard pull.

Q. Why a very hot fire?

A. So I could start the pumps full without impairing or cutting the pressure.

Q. When would you start your pump?

A. As soon as fairly started up the hill.

Q. Why?

A. As most hills have two sides, I would start them full in order to have a safe gauge to go down, without stopping to pump up.

Q. What would a careful engineer do before starting to pull a load over a steep hill?

A. He would examine his clutch, or gear pin.

Q. How would you proceed to figure the road speed of a traction engine?

A. First determine the circumference of the driver, then ascertain how many revolutions the engine makes to one of the drivers. Multiply the number of revolutions the engine makes per minute by 60, this will give the number of revolutions of the engine per hour. Divide this by the number of revolutions the engine makes to the drivers once, and this will give you the number of revolutions the drivers will make in one hour. Multiply

this quotient by the circumference of the driver in feet; the product is the number of feet the engine travels in one hour. To find out how many miles the engine can travel per hour divide the last product by 5280.

PUMPS

Every boiler should have two boiler feeders, either two pumps or two injectors, or an injector and a pump. Both of them should be in good working order all the time, as the safety of the boiler depends entirely upon them. It does not matter very much what particular boiler feeder is used so long as it is in good working order. There are dependent pumps and independent pumps, single tube and double tube injectors. They all may be made to work satisfactorily and with about equal certainty.

The question is often asked, "Which is more satisfactory, a cross head pump or one of the independent pumps?" This is a question that is not easily answered off hand. It depends a good deal upon circumstances and upon the engineer's knowledge of machinery. The cross head pump is a little easier to manage as a rule, than the independent pump, but it has a disadvantage of never running except when the engine runs. It is the simplest pump made and rarely gives any trouble. All that is necessary to do in order to stop it is to shut off the water

supply. The independent pumps are very satisfactory and will run whenever there is steam pressure enough in the boiler to move the piston in the pump. They are arranged generally to heat the feed water and are not very wasteful of steam. In fact, so far as economy is concerned it does not matter particularly what type of boiler feeder is employed for traction engine purposes.

Injectors of both, the single and double tubed type, have been used and are used widely. They are simple, easy to take care of, and are ready to work at a moment's notice whenever the steam pressure is within their range of action. They are singularly free from complex moving parts and are not difficult to repair.

Nearly all injectors are built on the same plan. In fact, there is so little difference between the injectors that are on the market today, and those that were first built, that it is almost safe to say there has been no marked improvement in them since the beginning. This is not strictly true, but it shows that the injector was very well perfected by the original inventor. All of the injectors now offered are well proportioned and suitable for the purpose intended. The best one to buy, perhaps, is the one that can be the most easily attached. In general, I would advise using the same style of injector whenever a new one has to be ordered. For traction engine work the automatic injector is the only one worth considering. The characteristic feature of the automatic in-

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See article on Standard Engines, Page 119.

jector is its ability to pick up and go on working again automatically after the suction has been broken.

An ordinary suction pump will draw water, theoreticaly, 34 feet; practically the limit is reached at about 24 or 25 feet. The pressure of the atmosphere is about 14.7 pounds per square inch and it takes 2.3 feet of water to produce a pressure of one pound, or in other words, a column of water one inch square and 2.3 feet high will weigh just one pound. The 14.7 pounds atmospheric pressure, therefore, will support a column of water 2.3 times 14.7 or 33.81 feet high. These are theoretical figures. In the case of a pump there is a slight leakage of air by the piston, then there is the impossibility of securing a perfect vacuum and the friction and weight of the valve to overcome. All of these things taken together make it impossible to lift water with a suction pump more than 25 or 26 feet as stated above. The lifting capacity of an injector is due to atmospheric pressure just the same as in the case of a pump.

The jet of steam when it first passes into the injector goes out through the overflow and carries with it air in the suction hose. Atmospheric pressure acting on the surface of the water presses the water up into the injector, where it is acted upon by the steam. The steam gives the water a high velocity, and is at the same time itself condensed. The combined stream of steam and water, having a higher velocity than the water would

have, if allowed to run freely from the boiler, can overcome boiler pressure and enter the boiler without difficulty. Since the injector makes use of atmospheric pressure in lifting water it is evident that its limit, theoretically, is the same as that of the pump. Practically about 20 feet is its limit of vertical lift. Ejectors and syphons are instruments which make use of the injector principle for lifting water from a lower level and delivering it to a higher. These machines are made with large jets and are suitable for handling large quantities of water. They have not the forcing capacity of injectors.

OIL

It is very difficult to advise any one what brand of oil to use. The same kind of oil is sold in various parts of the country under different trade names. Furthermore, oil is adulterated in a great variety of ways. There is probably more fraud practiced in connection with lubricating oils than anything else the engineer has to deal with. The fraud in this line can be compared only with the fraud in food products. It is a very easy matter to adulterate an oil because very few engineers know how to test an oil or really know a good oil from a poor one. There are thousands of engineers who understand the mechanical side of engineering very well, but who are entirely ignorant in regard to oils. The fact that an oil has considerable body or vicosity is no index of its purity

or of its suitability as a lubricant. Some of the poorest grades of oil show a very high flash test, good viscosity and a number of other good qualities supposed to be possessed by first class oils. Still as a lubricant they are worse than nothing at all. Probably no class of people are imposed upon in the matter of oils more than the threshermen, and no class of engineers have been defrauded more consistently and continuously than they. Perhaps it is not exaggerating conditions to state that half of the cylinder oil used in traction engines is worthless. It has a high flash test because of the fact that it contains a large amount of tarry matter. It has considerable viscosity for the same reason, but as a lubricant it has very little value. Worn valves, worn pistons and many of the accidents which occur in the cylinders of steam engines and frequently the lack of power of the engine may be traceable directly to these inferior oils, which are sold through local dealers all over the country at a very good prices. The statement has been made time and again that the engineer should, when he finds a good grade of oil, stick to it. This is good advice. The only difficulty is to find the good grade, but when found it is cheap at almost any price. A good cylinder oil should be clear and not too heavy. Ordinarily it will not have a very high fire test or flash test, as a high flash test is an indication of an impure oil when used for steam purposes. Good cylinder oil moreover, should not contain

acid. It should be practically neutral. The presence of free acids in any considerable proportions will cause the pitting of the cylinder and the follower or the follower bolts in the piston and stud bolts in the cylinder head.

LUBRICATORS

There are two kinds of lubricators used for traction engine cylinder lubrication, hydrostatic lubricators and oil pumps. The hydrostatic lubricator makes use of the pressure of a column of water to force the oil into the feed pipe. This column of water is obtained through the condensation of the steam and forms a column of from one to two feet in height, depending upon how the connections upon the lubricator are made up. In the single connection lubricator the length of the water column is from the top of the vertical loop to the bottom of the oil reservoir, usually from twelve to fifteen inches. The oil floats up through the sight-feed glass and from there passes through the horizontal oil pipe to the main steam pipe, where it is caught by the current of steam and atomized on its way to the steam chest and cylinder. If the oil is dirty it may cause trouble by forming an incrustation at the end of the oil nozzle in the sight-feed glass, which may deflect the oil against the sides of the glass, thus preventing it from flowing freely into the cylinder. In these lubricators water is introduced at the bottom of the reservoir. Oil is forced to the top and out

through a small pipe which leads downward from the upper part of the reservoir to the oil nozzle at the bottom of the sight-feed glass. The oil is therefore forced out by the entrance of water and this water is obtained from the condensation of steam in the pipe connections or loop of the lubricator. This type of lubricator has been used for a great many years and has been, in general, found very satisfactory but in the past few years it has given way to oil pumps and now nearly every well equipped traction engine is equipped with some sort of pump. There are dozens of these on the market nearly all of which give satisfaction under proper conditions. Some are a trifle simpler than others and perhaps are a little less liable to get out of order. Those, however, that have been on the market for three or four years have been redesigned and improved and are now entirely suitable for the work that is expected of them. On the whole, an oil pump is superior to a lubricator for traction engine cylinder work on account of the positiveness of the feed and its ability to handle oil under all sorts of weather conditions. In fact, oil pumps are taking the lead for lubricating pumps in all kinds of machinery, either stationary or portable.

OILING GEARING

The gearing of traction engines, especially those that are required to do heavy road work or plowing, should

be oiled continuously. The work which these gears are required to do is equal to the full capacity of the engine. They are required to transmit this power under adverse conditions. They are always working in the dust and dirt, the gears themselves are rough and they are mounted upon a more or less flexible foundation; all of this has a tendency to make the gears cut and grind and it is necessary in order to keep them in any sort of condition to oil them continuously. It would be better if the gears could be arranged to run in an oil bath, but generally this is not practicable. The next best thing to do is to cause a stream of drops of oil to fall upon the gears all the time they are at work. There are some traction engines arranged with an oil pump and reservoir for oil which supplies all that is necessary. I have always considered this a very good plan. Some are in the habit of using an axle grease or some grade of hard oil. The lubricating properties of this oil are satisfactory enough, but it is sticky and catches dust and dirt, and has a tendency to cut the gears almost as badly as though there was no oil present. The better scheme is to have liquid oil dropping on the gear teeth and carrying dust and dirt with it as it drips from the teeth. In this way what dust does get caught will soon be washed off and the gear teeth will not be cut very badly.

DIRECTIONS FOR PUTTING ENGINE ON DEAD CENTER

1. Take up all lost motion in the cross head, connecting rod, crank pin, and main bearings.

2. Turn the engine a little above or a little below center. The crank will be at, say, A, in the figure.

3. Make a punch mark on the engine frame at any convenient point as at B, then with a tram, like the one shown in the figure, one end of which is held at B, mark C on the rim of the fly wheel, crank or disc.

4. Now make a punch mark on the cross head and another at some convenient place on the guides, as D and E, and set a pair of dividers with the points in these two marks.

5. Next turn the engine past center until the cross head comes to the same position as before, and the points of the dividers will exactly fit into the two marks D and E. The crank is now on the other side of center just exactly as far as it was past center in the opposite direction.

6. With the end of the tram in position B, make another mark F, on the rim of the fly wheel. Now

find by careful measurement, a point on the wheel G exactly midway between C and F. If the engine is now turned until the points of the tram just fit into the marks B and G, the engine will be on dead center. The other dead center should now be found by an exactly similar process.

DIRECTION FOR SETTING A PLAIN SLIDE VALVE

1. See that the set screw in the eccentric is set tightly; then turn the engine fly wheel completely around, and observe if the valve uncovers one port as much as it does the other. If not, adjust the valve on its stem until it does.

2. Put the engine on dead center by means of the trams; then turn the eccentric in the direction the engine is to run until it shows the correct amount of lead—about one-thirty-second of an inch on the side nearest the piston.

3. Secure the eccentric in this position and place the engine on the other dead center and see if the lead is the same.

4. If the lead is not the same, correct one-half of the error by moving the valve on its stem and the other half by moving the eccentric. The valve will now be correctly set.

5. If the measurements in item No. 1 were accurately made, the correction noted in item No. 4 will not be necessary.

6. If no rocker arm, or a direct rocker arm intervenes, the correct position of the eccentric is about 120 degrees ahead of the crank. If there is an indirect rocker arm the eccentric will be about 60 degrees behind the crank.

"*Read,*" read anything that will give you a better understanding of steam and its uses. Learn to think for yourself by carefully proving or disproving every theory or argument that may be advanced by anyone, and "Rough and Tumble" is a good thing to commence on; but don't be ashamed to acknowledge that you have read it and if you approve of it don't hesitate to say so.

Only a short time ago I read an article in The American Thresherman from a party who stated that he did not believe in reading books on engineering and stated that all he knew he had learned in the field, and to prove what he knew about the working of a valve, copied an article word for word that I had written in the first edition of "Rough and Tumble." Now I don't object to his copying the article; I think he was making good use of his time while he was at it. But to copy an article and then say he never read a book in order to make it appear that the ideas were his was a questionable performance in my judgment.

SOMETHING ABOUT PRESSURE

Now before bringing this somewhat lengthy lecture to a close (for I consider it a mere lecture, a talk with the boys), I want to say something more about pressure. You notice that I have not advocated a very high pressure; I have not gone beyond 125 lbs., and yet you know and I know that very much higher pressure is being carried wherever the traction engine is used, and I want to say that a very high pressure is no gauge or guarantee of the intelligence of the engineer. The less a reckless individual knows about steam the higher pressure he will carry. A good engineer is never afraid of his engine without a good reason, and then he refuses to run it. He knows something of the enormous pressure in the boiler, while the reckless fellow never thinks of any pressure beyond the 100 or 140 pounds that his gauge shows. He says, "Oh! that—that ain't much of a pressure, that boiler is good for 200 pounds." It has never dawned on his mind (if he has one) that that 140 pounds mean 140 pounds on every square inch in that boiler shell, and 140 on each square inch of tube sheets. He ought to be able to thoroughly appreciate

this almost inconceivable pressure. How many engineers are today running 18 and 20 horse power engines that realize that a boiler of this diameter is not capable of sustaining the pressure he had been accustomed to carry in his little 26 or 30 inch boiler? On page 139 you will get some idea of the difference in safe working pressure of boilers of different diameters. On the other hand this is not intended to make you timid or afraid of your engine, as there is nothing to be afraid of if you realize what you are handling, and try to comprehend the fact that your steam gauge represents less than one 1-1000 part of the power you have under your management. You never had this put to you in this light before, did you?

If you thoroughly appreciate this fact and will try to comprehend this power confined in your boiler by noting the pressure, or power exerted by your cylinder through the small supply pipe, you will soon be an engineer who will only carry a safe economical pressure and if there comes a time when it is necessary to carry a higher pressure, you will be an engineer who will set the pop back again, when or as soon as this extra pressure is not necessary.

If I can get you to comprehend this power proposition no student of "Rough-and-Tumble Engineering" will ever blow up a boiler.

When I started out to talk engine to you I stated plain-

ly that this book would not be filled up with scientific theories, that while they were very nice they would do no good in this work. Now I am aware that I could have made a book four times as large as this, and if I had it would not be as valuable to the beginner at it is now.

From the fact that there is not a problem or a question contained in it that any one who has a common school education can not solve or answer without referring to any text book, the very best engineer in the country need not know any more than he will find in these pages. Yet I don't advise you to stop here, go to the top if you have the time and opportunity. Had I taken up each step theoretically and given formulas, tables, rules and demonstrations, the young engineer would have become discouraged and would never have read it through. He would have become discouraged because he could not understand it. Now to illustrate what I mean, we will go a little deeper and then still deeper, and you will begin to appreciate the simple way of putting the things which you as a plain engineer are interested in.

For example on page 139 we talked about the safe working pressure of different sized boilers. It was most likely and natural for you to say, "How do I find the safe working pressure?" Well, to find the safe working pressure of a boiler it is first necessary to find the

total pressure necessary to burst the boiler. It requires about twice as much pressure to tear the ends out of a boiler as it does to burst the shell, and as the weakest point is the basis for determining the safe pressure, we will make use of the shell only.

We will take for example a steel boiler 32 inches in diameter and 6 ft. long, 3/8 inch thick, tensile strength 60,000 lbs. The total pressure required to burst this shell would be the area exposed times the pressure. The thickness multiplied by the length, then by 2 (as there are two sides) then by the tensile strength equals the bursting pressure: $3/8 \times 72 \times 2 \times 60{,}000 = 3{,}240{,}000$. The total bursting pressure and the pressure *per square inch* required to burst the shell is found by dividing the total bursting pressure 3,240,000 pounds by the diameter times the length $3{,}240{,}000 \div (32 \times 72) = 1406$ lbs.

It would require 1406 lbs. per square inch to burst this shell if it were solid, that is if it had no seam, a single seam affords 62 per cent of the strength of shell, $1406 \times .62 = 871$ lbs. to burst the seam if single riveted; add 20 per cent if double riveted.

To determine the safe working pressure divide the bursting pressure of the weakest place by the factor of safety. The United States Government uses a factor of 6 for single riveted and adds 20 per cent for double riveted $871 \div 6 = 145$ lbs., the safe working pressure of this particular boiler, if single riveted.

Now suppose you take a boiler the same length and of the same material, but 80 inches in diameter. The bursting pressure would be 3,240,000 ÷ (80x72) = 560 lbs., and the safe working pressure would be 560 ÷ 6 = 93 lbs.

You will see by this that the diameter has much to do with the safe working pressure.

All of which is nice for you to know, and it may start you on a higher course, but it will not make you handle your engine any better on the road or in the field.

Suppose we give you a little touch of rules, and formulas in boiler making.

For instance you want to know the per cent of strength of single riveted and double riveted as compared to solid iron. Some very simple rules, or formulas, are applicable.

Find the per cent of strength to the solid iron in a single-riveted seam, ¼ inch plate, ⅝ inch rivet, pitched or spaced 2 inch centers. First reduce all to decimal form, as it simplifies the calculation: ¼ = .25 and ⅝ inch rivets will require eleven-sixteenth inch hole, this hole is supposed to be filled by the rivet, after driving, consequently this diameter is used in the calculation, eleven-sixteenths inches equals .6875.

First find the per cent of strength of the sheet.

$$\text{The formula is } \frac{P-D}{P} = \text{per cent.}$$

P = the pitch, D = the diameter of the rivet hole, per cent = per cent of strength of the solid iron.

$$\text{Substituting values, } \frac{2-.6875}{2} = .66.$$

Now, of course, you understand all about that, but it is Greek to some people.

So you see I have no apologies to make for following out my plain comprehensive talk, have not confused you, or lead you to believe that it requires a great amount of study to become an engineer. I mean a practical engineer, not a mechanical engineer. I just touch mechanical engineering to show you that that is something else.

If you are made of the proper stuff you can get enough out of this little book to make you as good an engineer as ever pulled a throttle on a traction engine. But this is no novel. Go back and read it again, and every time you read it you will find something you had not noticed before.

It is acknowledged by all that the varying duties of an engine today necessitate arrangement for quickly changing the speed of the engine to suit the various duties and this must be done by some simple contrivance to insure efficiency and durability. Many devices have been attempted which have been efficient at the start, but, due to complication and delicacy of the parts, resulted in rapid depreciation. The illustration here shown of the Pickering Ball Ranger will impress anyone with its marked simplicity. As will be noticed, steel balls are forced between the rods leading to top of governor and the one on which the valve is hung, which quickly locates the valve to the required load and speed. By turning in on the screw, the valve is lowered, or by backing out on this screw, the balls are released and allow the valve to raise. After finding the correct position, the adjustment is locked by means of the small barred nut which is shown.

In the Pickering Governor no change is made in tension of the spiral spring for change in speed, the spring merely being to support the valve or adust the Governor to individual conditions, therefore, once securing the proper tension on this spring no further adjustment is made and the tension not being excessive, the springs prove exceedingly durable. Change in speed through spring adustment is not correct, but should be made independent of the spring and which is accomplished by the Ball Ranger.

There are no joints in the Pickering Governor, and this accounts for its closeness of regulation, marked stability, and freedom from wear. The same construction is observed in the Ranger, there being absolutely no joints and no possibility for wear. This Ranger was devised by people who have had practical experience in the regulation of engines for many years and who have always paid particular attention to efficiency, with durability, because durability is a very important item to the user and secures continual efficiency.

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